YEARBOOK

OF THE

UNITED STATES

DEPARTMENT OF AGRICULTURE.

1894.

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AN ACT providing for the public printing and binding and the distribution of public documents.

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Section 73, paragraph 2:

The Annual Report of the Secretary of Agriculture shall hereafter be submitted and printed in two parts, as follows: Part one, which shall contain purely business and executive matter which it is necessary for the Secretary to submit to the President and Congress; part two, which shall contain such reports from the different bureaus and divisions, and such papers prepared by their special agents, accompanied by suitable illustrations, as shall, in the opinion of the Secretary, be specially suited to interest and instruct the farmers of the country, and to include a general report of the operations of the Department for their information. There shall be printed of part one, one thousand copies for the Senate, two thousand copies for the House, and three thousand copies for the Department of Agriculture; and of part two, one hundred and ten thousand copies for the use of the Senate, three hundred and sixty thousand copies for the use of the House of Representatives, and thirty thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture; and the title of each of the said parts shall be such as to show that such part is complete in itself.

PREFACE

The Yearbook of the Department of Agriculture for 1894 has been prepared in compliance with section 73 of the "act providing for the public printing and binding and the distribution of public documents," approved January 12, 1895, and in accordance with the instructions of the Secretary of Agriculture based thereon.

The Annual Report of the Secretary of Agriculture, which has of late years been published in an edition of half a million copies for distribution to the farmers of the country, chiefly by Senators, Representatives, and Delegates in Congress, while comprising the administrative reports of the Secretary and the chiefs of bureaus and divisions, had, perhaps unavoidably, included discussions of the investigations carried on in the Department, and contained matter better suited to scientific monographs. The report has been chiefly useful on account of these papers, and not on account of details of the administrative business of the Department. The separation of the scientific reports and other useful information designed for the instruction of the ordinary citizen from the purely executive and business matter has been accomplished by the publication of the latter, as provided in the act of January 12, 1895, by itself, as a part of the Message and Documents Communicated to the two Houses of Congress, while special reports and papers contributed from the several bureaus and divisions, suited to interest and instruct the farmers of the country, and including, for their information, a general report of the operations of the Department, are here presented under the title of "Yearbook of the United States Department of Agriculture for 1894."

The present volume represents but imperfectly the ideal of what such a yearbook should be. The matter of the change of character of the report was not considered until many of the papers for the usual annual report had been prepared and submitted, and the law did not finally pass until after the usual time for filing the report. The best that could be done under the circumstances, therefore, was to select from the matter in hand the most meritorious papers, representing a variety of different lines of work carried on in the Department, and to adapt them to the purposes of the new publication.

This volume is divided into three sections:

First. The Report of the Secretary of Agriculture for 1894, giving a general account of the operations of the Department during the year.

Second. A series of papers, prepared for the most part by the chiefs of bureaus and divisions and their assistants, discussing either the general work of their bureaus or divisions, or particular lines of work with special reference to interesting and instructing the farmer.

Third. An appendix made up of statistical tables and information useful for reference, compiled in the various bureaus and divisions.

It is believed that the character of the volume can be improved from year to year until it shall become finally a standard book of reference for American farmers.

Public Printer Benedict has cordially cooperated with this Department in the effort to publish a book which in general appearance and mechanical work shall be far superior to any former annual report. The object has been to illustrate the book as fully as possible with text figures made by the very best methods, to print it on good paper, and bind it in a substantial manner. In order to enable him to make these improvements it was found necessary to omit all the colored lithographic plates, the expense of which in the past has far surpassed their value to the general reader.

Since the Government prints half a million copies of this publication, at an approximate cost of $300,000 annually, to say nothing of the expense of distribution, every addition to the practical value of the book becomes a matter of the utmost importance.

It is believed that future numbers of this yearbook will still more fully justify the new departure, and it is hoped that in the meantime the present volume will be received rather as a promise and an earnest of improvement than as a fulfillment of the purpose contemplated by the change.

CHAS. W. DABNEY, Jr.,
Assistant Secretary.

WASHINGTON, D. C., *June 8, 1895.*

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YEARBOOK

OF THE

U. S. DEPARTMENT OF AGRICULTURE.

REPORT OF THE SECRETARY OF AGRICULTURE.

Mr. PRESIDENT:

In compliance with law and custom, the Secretary of Agriculture has the honor now to submit the Annual Report for that Department for the fiscal year ending June 30, 1894. The data, statements, and suggestions contained herein show how much work has been performed, how many people have been employed, what expenses have been incurred, what improvements have been made in the service as to efficiency, and what economies in disbursements have been effected.

A critical perusal of the work of each bureau and division, as herein narrated, will impress the conclusion that, while six hundred thousand dollars ($600,000) have been covered back into the Treasury out of the annual appropriation—the same being 23 per cent of the entire sum set apart for the use of the Department of Agriculture for that fiscal year—economy has not diminished efficiency.

FOREIGN MARKETS FOR AMERICAN FARM PRODUCTS.

During the year the labor of finding where the greatest demand for the surplus farm products of the United States has developed outside of their limits has been persistently and intelligently alert and active.

There is nothing of greater or more vital importance to the farmers of the United States than the widening of the markets for their products. It is the demand for wheat, the demand for beef, the demand for pork, the demand for all the products of human industry which confers a money value upon them in markets. Therefore, the relation of supply to demand is the creator of prices and the sole regulator of values. Holding such views, the Secretary of Agriculture has carefully studied and enumerated the demands for American agricultural products in the principal markets of the world.

THE FARMER'S PRINCIPAL BEEF MARKET.

During the nine months ending September 30, 1894, the farmers and stock raisers of the United States have sold, and there have been exported, to the United Kingdom of Great Britain three hundred and

five thousand nine hundred and ten (305,910) live beef cattle, valued at twenty-six million five hundred thousand dollars ($26,500,000). During the same period of the year 1893 only one hundred and eighty-two thousand six hundred and eleven (182,611) live beef cattle from the United States were taken by the British markets, at a valuation of sixteen million six hundred and thirty-four thousand dollars ($16,634,000). The small consumption of American beef in England last year was due to restrictions imposed by law, and also to the low prices of domestic beef in England, because of the scarcity there of feeding stuffs, which enforced slaughtering. The increase of the present year does not quite restore the average of the cattle trade between the United States and England. Canada is practically the only competitor with the United States for the English live-cattle trade. The regulations governing the importation into England of live stock are the same as to animals from the United States and Canada, no discrimination being made for or against either class. All of the animals are, under the provisions of English law, slaughtered immediately upon arrival at British ports.

Large proportions of the meat thus taken into England are sold in the retail markets of London, Liverpool, and other cities, as "prime Scotch" or "English beef." Under that classification the butcher demands and secures a better price than he could with the meat known and sold as Canadian or American. This method is a splendid indorsement of the quality of American beef. It has, however, been the occasion of much contention, and at last resulted in a Government investigation. The official report of a select committee of the House of Commons on "the marking of foreign meat" was published in August, 1893. It states in the summary, on the evidence taken before the committee, that in "large West End of London" establishments which profess to sell nothing but English and Scotch meats there is practically no other meat than American sold. The committee show that in each case the prices charged were such as would be justified only had the meat been purchased, wholesale, at the price commanded by the best English fattened and killed meat. The conclusions of the committee of the British House of Commons were to the effect that it would be a vexatious and unworkable scheme to attempt to compel the labeling, as to its origin, of each piece of meat offered for sale. The committee suggested that butchers dealing in imported meats should be compelled to register themselves as such dealers, and also pay a fee which might be applied toward defraying the costs of meat inspection. Nothing, however, has been done in pursuance of the recommendations of this committee.

In England it is not believed that legislation can prevent the sale of American and other imported fresh beef as Scotch and English beef. The beef from the United States is of such excellent quality and so very similar to the best English beef that even experts are unable to

distinguish between the two. Any law which might be enacted would fail to repress the sale of American meat in English markets. The statute, however, might curtail the profits of butchers. The lower price which they could only obtain for imported meat, sold as such, would have a direct tendency to increase its consumption, and thus to make more demand for American beef.

The trade in live cattle between the two countries has been of the greatest advantage to the British people. During the six months of the year from March to September, when their cattle are fattening on the pastures, American steers are arriving in large quantities and of superior condition and flavor. Long ago it would have been generally admitted in England that American beef is superior, from March to September every year, to English beef produced during those six months, except for a certain national prejudice which is common to all countries.

During the year regulations have been made which compel the Canadian cattle to be slaughtered at the port of debarkation. These regulations interfere somewhat with the United States beef trade. Formerly Canadian cattle were put in English pastures and fattened. Now, like those from the United States, they must be killed immediately upon arrival. Cargoes of Canadian and American cattle arriving simultaneously at a British port, both being ordered to slaughter at once, would naturally at such times momentarily depress prices. As a rule, Canadian cattle are not equal in condition to ours. They generally bring smaller prices. Canadian distillery-fed cattle, however, are very fine, and command higher figures. At the present moment there are three times as many Canadian cattle being fed at distilleries for export as were fed last year. American shippers may, therefore, look for that competition in the spring. It may not be considered very important, however, as the number will not exceed 20,000 at furthest; but the competition is worth noticing.

The live-beef trade is conducted at different ports with slight differences. At Deptford sales are private on the hoof. At Liverpool half of the animals are sold privately. The other half are slaughtered on account of shippers and sold to buyers by the carcass. The Liverpool surplus makes its way to London, and a large part of it, beyond question, is so "cut up" as to simulate "prime Scotch joints." At Glasgow and Bristol nearly all animals are sold at auction on the hoof. The charges do not differ very materially at the various ports. The following may be taken as the average costs at each place of debarkation: Dock dues, use of slaughterhouse, etc., $1.20 per head; subsistence per day, 24 cents; commission of salesman on each animal, 96 cents; driving (feeding, attending, etc.), 24 cents. The shipper who gets out with British terminal charges of $3.75 per head upon his cattle considers himself fortunate. Add to the above charges, freight $11, and $1.50 for the feed and attendance of each animal on the

voyage, and $1.60 for insurance, and we have a total expense for each animal shipped of $17.85. This represents very nearly accurately the expense of getting a beef animal from the American port into the hands of the British buyer.

October 25, 1894, good American steers were bringing in the British market $85 each. The best weight of cattle for shipment is 1,350 to 1,400 pounds, making a dead weight of about 750 pounds. In England the offal (especially in London and Liverpool, where large numbers of poor people purchase it) is considered of great importance. Heads, tails, livers, kidneys, lights, and hoofs go to one buyer, and the hides and inside fat to another. Parliament disinclines toward the encouragement of a trade in dressed meat, because that would shut out the offal; but if the American cattle are killed at home, properly dressed, and sent to Europe in a state of refrigeration, the cost of American beef will be reduced in all those markets. By killing at home and shipping only the dressed carcasses, bulk is compacted, value is enhanced, and the cost of transportation is reduced, so that the poor, who heretofore have bought offal, may be able to buy good meat instead.

During the first six months of the year 1894 there were exported to the United Kingdom of Great Britain one hundred and twelve million (112,000,000) pounds of dressed beef, valued at nearly ten millions of dollars. This trade in dressed beef is almost entirely in the hands of American citizens. Their principal competitors are found in Australasia. The question whether more profit remains with the producer from shipping live beef cattle or carcasses to European markets is one which requires thorough investigation. At the present writing it is deemed probable that more advantage and profit will result to the American farmer from the shipment of dressed beef than from the exportation of live cattle.

European governments are constantly declaring live animals from the United States diseased. These declarations are sometimes made for fear of infection of their own herds, and at other times, it is believed, for economic reasons. If all American beef going abroad is shipped in carcasses, and it is all stamped "inspected" as wholesome and edible, by authority of the Government of the United States, it certainly can not be shut out afterwards on account of alleged Texas fever, pleuropneumonia, tuberculosis, or any other disease. But if certain European nations continue to demand legally authorized microscopic inspection of American pork and require also veterinary inspection for beef with Government certification to each, then why ought not the Government of the United States to demand that all imports from foreign countries for human consumption—either edibles or beverages—must likewise be certificated by the authorities of those foreign governments as wholesome and unadulterated before they are permitted to be sold in the United States?

AMERICAN HOG PRODUCTS.

Besides consuming such a vast proportion of the beef exported from the United States, the United Kingdom of Great Britain is likewise a voracious customer for American bacon, hams, and lard. Between 20 and 25 per cent of the flesh food of the people of the United Kingdom consists of hog products. About 13 per cent of those hog products comes from other countries, and 14 per cent of the live cattle and dressed beef and mutton is also imported.

There were taken into the United Kingdom from the United States, in 1893, two hundred and forty-three million eight hundred and twenty-four thousand (243,824,000) pounds of bacon, valued at twenty-six million eight hundred and fifty thousand dollars ($26,850,000).

During the nine months ending September 30, 1894, the United States sent into England two hundred and twenty-two million six hundred and seventy-six thousand (222,676,000) pounds, against one hundred and seventy-nine million eight hundred and seventy-two thousand (179,872,000) pounds during the corresponding nine months of 1893. Thus our trade with Great Britain in hog products shows an increase of nearly forty-five million (45,000,000) pounds this year. This, however, does not restore to us the position we occupied prior to the year 1893 as principal purveyor to Great Britain. Nor do the values make as good a showing as they should; for, notwithstanding the increase in quantity, there is a shrinkage in value of half a million of dollars; while the bacon imported to the United Kingdom during the same period increased fifty-six million pounds. The hog products from other countries than the United States did not fall in value proportionally with ours. This is shown by the market quotations throughout the year.

Imports of pig products, beef, mutton, etc., into the United Kingdom during the first nine months of the years 1892–1894.

[From the official returns of the British Board of Trade.]

Product.	Imports for first nine months—			Value of imports first nine months—		
	1894.	1893.	1892.	1894.	1893.	1892.
Bacon:						
From Denmark....cwt..	607,577	542,496	530,814	$8,614,882	$7,988,400	$7,305,375
Germany......do..	300	9,499	2,987	4,275	141,666	36,546
Canada........do..	178,878	113,626	189,999	1,790,871	1,415,041	1,763,800
United States .do..	1,988,203	1,606,348	2,295,841	19,357,376	19,857,315	20,031,048
Other countries, cwt	73,542	77,336	53,247	950,712	998,578	677,368
Total	2,848,500	2,349,305	3,072,888	30,717,916	30,401,000	29,814,137
Hams, bulk, United States, cwt.....................	887,740	757,609	1,013,044	10,704,687	11,067,636	11,545,579
Beef (salted), United States, cwt.....................	178,156	145,422	204,737	1,261,967	947,742	1,425,879

Imports of pig products, beef, mutton, etc.—Continued.

[From the official returns of the British Board of Trade.]

Product.	Imports for first nine months—			Value of imports first nine months—		
	1894.	1893.	1892.	1894.	1893.	1892.
Beef (fresh):						
From United States.cwt..	1,350,635	1,109,396	1,434,813	$13,995,094	$11,958,870	$15,106,349
Other countries, cwt	243,118	223,271	96,784	1,778,705	1,889,774	763,973
Pork (salted):						
From United States.cwt..	107,335	80,965	125,494	853,440	730,400	846,775
Other countries, cwt	59,869	59,514	55,468	398,620	353,080	302,559
Pork (fresh):						
From Holland ......cwt..	77,491	79,515	49,342	888,079	928,950	581,111
Belgium......do..	16,638	16,159	11,063	203,523	195,642	131,952
Other countries, cwt	15,019	23,844	6,189	198,844	313,474	65,488
Total	109,148	119,518	66,594	1,289,066	1,438,066	778,551
Meat (unenumerated):						
From Holland.......cwt..	83,118	91,294	79,978	882,086	997,222	885,384
United States..do..	21,710	15,784	16,785	195,802	164,549	174,744
Other countries, cwt	33,431	30,626	18,704	386,470	350,913	214,879
Total	138,259	137,704	115,467	1,464,358	1,512,684	1,275,007
Meat (preserved otherwise than by salting):						
Beef ....cwt..	193,044	264,805	399,882	2,674,043	3,253,040	4,820,362
Mutton..............do..	85,069	64,023	47,825	723,779	584,957	465,942
Other sorts..........do..	108,950	99,961	128,169	1,715,507	1,730,786	1,811,602
Total	387,063	428,789	575,876	5,113,329	5,568,783	7,077,906
Mutton (fresh):						
From Germany ....cwt..	7,017	16,335	19,857	83,007	199,269	249,674
Holland.......do..	92,646	98,498	73,902	1,028,625	1,101,809	865,334
Australasia...do..	1,082,519	949,232	796,933	10,226,000	9,202,762	7,945,568
Argentine Republic..........cwt..	424,958	384,297	354,500	3,735,288	3,499,960	3,185,367
Other countries, cwt.	58,826	51,531	48,355	637,626	574,009	570,633
Total	1,665,966	1,499,893	1,293,547	15,710,546	14,577,809	12,816,576

NOTE.—Cwt. = 112 pounds.

In the fall of 1893 English bacon was commanding nearly as high prices as in October, 1894. The decline in the best grades of Irish bacon during the same period represents about half a dollar per cwt. (112 pounds). There is some decline in Danish bacon and Canadian bacon. But United States side meats declined more than $2 per cwt. Cumberland cuts have been reduced by $3, and short ribs the same amount per cwt. There is also a similarly disproportionate decline in the values in England of United States lard.

Beside the general causes of depression in values of all commodities throughout the world, there is a special reason why values of hog

products should have been lower in Great Britain during the last year. The drought there during 1893 forced their domestic animals upon a glutted market. Thus the price of beef and mutton was brought down to a point where they were preferred as of superior value to bacon and hams. Another cause for the decline in hog products may be found in frozen dressed meats. Excellent mutton can be bought in England at the same price as bacon. Therefore a larger number of people who fifteen years ago seldom ate other flesh than salted swine flesh now purchase New Zealand, Falkland Islands, and other frozen imported mutton. In view of the low prices of meat and other food supplies pouring into England, there have only lately been expressions of surprise in the trade journals there that the prices of bacon are maintained even at present figures. But the British people are a bacon-eating people at breakfast every morning, and no competition of fresh meat is likely to alter their habit in this respect.

The cheaply imported frozen meat largely lessens the consumption of bacon among a numerous class of working people who formerly were exclusively buyers of our hog products, which then were the cheapest in the European markets. Thus a great change in their demand for meats—from salt pork to fresh mutton and beef—is one cause of the decline; but there is another reason more potent than this for the comparatively disproportionate fall of the price in the American hog product output throughout the European markets, especially in the United Kingdom. The demand there is for a mildly cured, not oversalted, and very lean bacon. The nearness to market at the point of producing gives to Danish bacon a great advantage. Therefore an astonishing growth of packing houses is witnessed upon the Continent, and particularly in Denmark. Danish bacon reaches the English market in twenty-four hours. It arrives in fine condition. It is cured to meet the English taste and demand. The best Danish brands bring within a dollar a cwt. of the best Wiltshire.

Thus a permanent and constantly increasing bacon trade has been built up between Denmark and England, which already amounts to more than fifty million pounds per annum. In October, 1894, Danish bacon is temporarily being diverted by the shortness of the hog crop in Germany from the markets of the United Kingdom. For a long time Germany put a stop by a high tariff duty to the shipment of Danish hogs into its domains. Before that prohibition they were shipped there to be made into bacon; but this year German packers are compelled, by the decline in the swine crop of that country, to import Danish swine and pay the duty thereon, to make up for domestic deficiencies.

What is gained by carefully studying the character of the demand of the foreign markets we seek to supply is well illustrated by the figures given above, showing the relative values and quantities of bacon exported to Great Britain by Denmark and the United States. While the price obtained for Danish bacon is $14.18 per cwt., that obtained for bacon from the United States is only $9.72 per cwt. In other words,

if the quality of the American bacon offered for sale in the British market had been as well adapted to the taste of the British consumers as the Danish, American bacon would have realized $28,192,300 instead of the $19,357,376 which it actually did realize.

The prohibition of American cattle by Germany will stimulate the Teutonic consumption of bacon. Therefore, indirectly, but not the less effectively, it will aid in lessening the Danish bacon capacity to compete in the British market with hog products from the United States.

The best brands of Canadian singed sides bring in England within a half dollar to a dollar per cwt. of the prices of the best grades of Danish bacon, and the Canadians command from a half dollar to a dollar more than the corresponding American cuts will bring. Canada, unlike Denmark, has no advantage over us geographically. Its seeming superiority in quality is due wholly to the fact that its hog carries 10 to 15 per cent more of lean and less of fat flesh than the American hog. It, therefore, more completely answers the taste and demands of the British public, and consequently commands a higher price. The imperious British demand for lean bacon is observed in the unceasing attempts of the great Wiltshire packers to obtain lean hogs. The firm of Charles & Thomas Harris, Limited, of Calne, England (Wiltshire), some time since began to offer a premium for medium-sized pigs. Their system of buying is the issuance of a weekly circular, stating the prices they are willing to pay for certain sorts of swine. A circular of this firm, issued in October, 1894, is as follows:

Present prices for prime pigs, in lots of not less than ten, on rail within 100 miles of Calne.

Prime stores.	Thickness of fat in any part of the back.	Price per 20 pounds.
		s. d.
130 pounds to 190 pounds	2¼ inches and under	7 6
Under 210 pounds	Not exceeding 2½ inches	6 9
Under 230 pounds	Not exceeding 2¾ inches	6 3
Under 240 pounds	Not exceeding 3 inches	6 3

This circular shows that they offered the largest prices for animals running from 130 to 190 pounds which carried not more than 2¼ inches of fat on the back. For such pigs they offered 7s. 6d. "per score"—that is, in our money, $1.80 per 20 pounds, or 9 cents a pound live weight. Under the Harris plan of purchase it is reported that the percentage of lean pigs sent to the Calne market in Wiltshire has risen from 47 to 75. The public demand for this sort of bacon has been met by the farmers by changing the breed. To do this they have raised Tamworths and Yorkshires to the exclusion of the Berkshires. The methods of this firm of English packers are enlarged upon for the reason that Wiltshire bacon is all through Europe recognized as the standard brand, and the house of Charles & Thomas Harris is known as the largest and

best Wiltshire packing concern. Therefore a knowledge of the methods which they pursue to maintain their goods in public esteem is in the highest degree valuable to the American packers and farmers. The fact is demonstrated that the bacon which commands the best price in the English market is a lean and not oversalted meat. In view of that fact, it is of interest to American producers to place themselves in a position to cater especially for a market which demands so much of this peculiarly fattened and particularly cured commodity.

The English lard market italicizes the fact that complaints from retail dealers throughout England are constantly being made, through their trade journals, regarding the short weights of American lard in pails. A prominent London trade journal of October 13, 1894, says:

> The result of carefully weighing 50 wood pails of a well-known American, bought, as usual, at shippers' weights and received by us about a fortnight ago, shows that the exact weight in each pail (each lid bearing the words "28 pounds net") was as follows: 11 pails weigned 27 pounds 2 ounces each; 12 pails weighed 27 pounds each; 3 pails, 26 pounds 14 ounces each; 15 pails, 27¼ pounds each; 2 pails, 27 pounds 6 ounces each; 1 pail, 26 pounds 10 ounces; 2 pails, 27½ pounds each; 1 pail, 27 pounds 10 ounces; 3 pails, 26¾ pounds each, making a shortage of 44 pounds on the lot. Retailers in England are combining against short lard weights generally, and there is a movement in some of the larger trade centers looking to the same end. The result may be a discrimination, amounting in many places to a boycott, against all brands which do not weigh out as marked.

The foregoing somewhat tedious details as to the meat trade of the United States with the United Kingdom of Great Britain have been secured by personal solicitation of the Secretary of Agriculture, and are perfectly reliable down to and inclusive of the first nine months of the year 1894. They accentuate the magnitude of that particular foreign market for surplus meat products of the farmers of the United States.

Worthington C. Ford, the very competent and diligent Chief of the Bureau of Statistics in the Treasury Department, has furnished the Department of Agriculture the following table, which represents the quantities and values of bacon, hams, pork, etc., shipped into the United Kingdom from the United States during the year ending June 30, 1894:

Product.	Quantities.	Values.
	Pounds.	
Bacon	334, 985, 389	$31, 366, 843
Hams	73, 894, 248	8, 230, 787
Pork, fresh and pickled	14, 272, 957	1, 159, 315
Lard	150, 655, 158	13, 528, 987

To Mr. Ford the American public is indebted for valuable statistical data further illustrative of the foreign markets and the amount of American farm products which they consume. In his summary statement of the imports and exports of the United States, corrected to March 1, 1894, it will be seen that during the seven months ending January 31, 1894, the United Kingdom of Great Britain took fourteen million

eight hundred and thirty-eight thousand three hundred and sixty-seven dollars' ($14,838,367) worth of live cattle from the United States, while all other countries took during the same period of time only two hundred and thirteen thousand eight hundred and fifty-five dollars' ($213,855) worth. During the one month of January, 1894, the United Kingdom of Great Britain took from the United States thirty-five million two hundred and forty thousand four hundred and thirty-one (35,240,431) pounds of bacon. The balance of the world took during the same time nine million five hundred and seventy-six thousand seven hundred and seventy (9,576,770) pounds. On page 565 of the summary statement referred to, under the head of "Domestic breadstuffs, etc.," exported from the United States, is a recapitulation showing the amount of breadstuffs, provisions, cotton, and tobacco exported from the United States by all countries during the year ending December 31, 1893.

This recapitulation shows that the United Kingdom paid to American producers during that year for breadstuffs, provisions, cotton, and tobacco more than three hundred and twenty-four millions of dollars ($324,000,000). That is to say, *the British market bought more than one-half of all the farm exports of the United States during that year.* Including mineral oils with agricultural exports (and there was only $10,131,473 worth of oil shipped), the United Kingdom of Great Britain took 54.31 per cent of all that was exported from the United States during that year. And the entire exports of breadstuffs, provisions, mineral oils, cotton, and tobacco from the United States to all parts of the world during that year aggregated six hundred and fifteen million five hundred and seventy-four thousand and eighty-six dollars' ($615,574,086) worth in value. A study of the world's markets demonstrates the fact to the producers of meat and breadstuffs in the United States that the United Kingdom of Great Britain furnished the largest demand for their commodities.

Besides taking so much of meat and breadstuffs the same country took, in the year ending September 30, 1894, one hundred and forty-one thousand two hundred and ninety-four (141,294) tons of hay from the United States; but, owing to the fine hay crop which has recently been secured in Great Britain, there will be a great falling off in this respect for the coming year.

Great Britain took thirty-one thousand five hundred and twenty (31,520) tons of cheese from the United States during the year which ended April 30, 1894, and of butter, for the same period, two thousand and twenty-one (2,021) tons. But Denmark furnished, in butter, in the same year to Great Britain, forty-eight thousand nine hundred and ninety-seven (48,997) tons. From these dairy figures one may reasonably conclude that the butter and cheese capabilities of the United States are only just beginning to be developed.

One of the lessons of this competition, especially accentuated by the conditions of the foreign dairy market, is that *quality* must be the

constant aim of the producer. Upon that Denmark has founded and developed her wonderful foreign dairy trade. As a producing country, competing against all the world in the world's markets, the high quality and integrity of our products must be firmly established and strictly maintained. Such a reputation is indispensable if we are to hold our place in the markets of the world.

WHEAT IN ENGLISH MARKETS.

The United Kingdom took in from foreign countries during the nine months ending September 30, 1894, nine million (9,000,000) bushels more wheat than during the same months in the year 1893; but the increased shipments into England of wheat were principally from Russia, the Argentine Republic, and Australasia. During that time the United States did not maintain its position as a wheat seller in England. In those nine months there was a falling off in American wheat upon the English markets of thirteen and a half million (13,500,000) Winchester bushels. The decline in value was proportionately far greater, and amounted to eight million four hundred and thirty-three thousand dollars ($8,433,000). A primary cause for the falling off of American wheat in English markets during the early part of this year is found in the fact that Argentina was a free seller, while our people maintained figures a trifle above the British market. On October 25, 1894, the market appears more inclined to higher figures. There is a distinct indication of activity and a better trade, with, however, only slightly improving prices. Appended hereunto is a table showing the prices of American and British wheat, and English barley, and beef and potatoes, during each month of the year 1894 down to and inclusive of September 28.

Prices of certain food products in Great Britain on the first day of each month (or thereabouts) of the year 1894.

Date.	American red winter wheat (per Winchester bushel).	English wheat (per Winchester bushel).	English barley (per bushel of 56 pounds).	Beef, inferior (cash, wholesale, per pound).	Beef, superior (per pound).	Potatoes (per ton).
1894.	Cents.	Cents.	Cents.	Cents.	Cents.	
January 5	77	76	88½	7½	14⅛	$14.60
February 2	78	76	88½	7	13⅓	12.77
March 2	77	70	85	6	13⅛	12.16
April 1	70	70	82	7	12⅝	10.33
May 1	75	71	86	7	13⅛	7.39
June 1	66	70	73	7	13⅝	9.73
July 1	64	70	62	8	13⅝	12.16
August 3	66	71	68	7	13⅝	*17.03
August 31	62	70	68	7	13⅝	15.78
September 28	57	57	71	7½	12⅝	17.00

* New.

NOTE.—These averages are official. In the original tables the figures for *red winter wheat* are expressed in sterling money per quarter of 496 pounds. These are translated into United States equivalents at the par value of the pound sterling (4.86\frac{65}{100}$) and in bushels of 60 pounds each. *English wheat* has for its unit the quarter of 504 pounds; English *barley*, the quarter of 448 pounds; flour, the sack of 280 pounds; beef, the London stone of 8 pounds.

These tables are of value to the American farmer. They illustrate the fact that the price of wheat is now, and must always be, governed by the relation of the supply of wheat to the demand for wheat. Improved farming implements and machinery have reduced the cost of production. Wheat will, in all probability, remain at relatively low figures in all time to come, except when there are failures of the crop in large wheat-growing sections of the earth. The great competitors of the United States in the production and sale of wheat are the Argentine Republic, Australasia, and Russia. The capabilities of the last-named country as a bread producer are beyond computation. Already American farm implements and machinery are finding enormous sale in that Empire, and permanently established agencies of the great reaping and other manufacturing concerns of the United States are solidly located at Odessa and other important entrepôts to the wheat-growing regions.

Looking at cheap bread from the standpoint of the consumer, the world is fed better and oftener than it ever was before. The profits of the producer are now divided, so that the consumer gets a large share thereof. But it matters very little to the producer of wheat in the United States what the price may be if he is permitted to buy in the markets where he is compelled to sell. In other words, if the price of the farmer's wheat is fixed in Europe, there is no good reason why the prices of the things he has to buy should not also be fixed in Europe. In *selling*, the farmer competes with all the world. To give him an equal chance he ought also to be allowed to *buy* where all the world competes. European and all other foreign markets for wheat indicate that the competition in that cereal is constantly increasing and intensifying. The Argentine Republic is capable already of placing thirty-five millions (35,000,000) of bushels of wheat a year on the European market, while it has only five millions (5,000,000) of population. The Argentine wheat fields average less than 100 miles from deep-water harbors. To reach shipping ports Argentine wheat pays no appreciable inland freight. But the wheat of the United States averages quite a heavy transportation charge in reaching the seaboard. In short, we have a long haul and the Argentine Republic a short haul before reaching the Atlantic. Russia, likewise, has the advantages of a short haul and speedy transportation.

There are many subsidiary crops to which the American farmer may profitably turn his attention. Wheat will not hereafter be our staple cereal product. Corn is constantly advancing in importance because of an ever-growing demand for that cereal which is evolved from the various new uses to which it is being constantly appropriated.

EXPORTS OF BARLEY.

There has been a steadily growing demand for barley exportation to Great Britain. This demand amounted during the first nine months of 1894 to an increase over last year of eighteen millions (18,000,000) of

bushels. The universal use of barley by brewers in England maintains a steady and constant market for the highest grades of that cereal. Hard, firm, and bright grain barley from the Northwestern States and California commands higher prices than many European barleys. That kind of American barley is second best to the best grade barleys of Smyrna, and is regarded among the best malting barleys in the British markets. The average yield per acre of barley in Great Britain is thirty-four (34) bushels, though the drought of 1893 reduced it to an average of only twenty-nine (29) bushels. There are two and a quarter million (2,250,000) acres, average, of barley in the United Kingdom annually, so that the annual product is something like seventy-five million (75,000,000) imperial bushels, though the harvest of 1893 shows only sixty-five million seven hundred and forty-six thousand (65,746,000) bushels.

In seven years the export of barley from the United States to Great Britain has grown from nothing into a very considerable trade. The average price in England during the year 1894 of good, bright barley, per bushel of 56 pounds, has been 77$\frac{1}{5}$ cents.

The supply of the best quality of malting barley is limited, but there are States in the American Union which have great advantages for the production of the very highest grades of this cereal, and the market seems to be a growing one into which American farmers can pour a large volume of remunerative products every year.

THE UNITED STATES APPLE TRADE WITH ENGLAND.

During the year 1892 England took in from the United States and Canada four and a half million (4,500,000) bushels of apples, valued at six and a half million dollars ($6,500,000). In the year 1893, however, owing to poor crops in this country and Canada, and not because of a want of a market in England, she purchased only three million four hundred thousand (3,400,000) bushels, valued at four million one hundred thousand dollars ($4,100,000); and during the nine months ending with September, 1894, Great Britain took one million nine hundred thousand (1,900,000) bushels of apples, valued at two and a half million of dollars ($2,500,000). The apple market in Great Britain during the spring is largely supplied from Australasia, New Zealand, France, and Italy, the import from the latter country being a novelty which was witnessed for the first time during the year 1894.

The English apple crop is gathered in the early autumn and partially supplies the markets until about the middle of September. Then the first shipments of American apples begin to arrive. They consist of summer fruit. They are very tender and require immediate sale. They are packed in what are known to the trade as "New York barrels," containing 3 bushels and running 1 cwt. in weight. These barrels are smaller by 25 pounds than those in which the Canadian apples reach that market. But it is rather an advantage to the American trade that

the barrel is smaller. It is not believed in Great Britain that if the barrel were made larger the corresponding increase in price could be obtained.

Canadian apples begin to arrive in London at the end of October. As a rule they are firm, hard, and fine colored, and command the best prices through the winter. American apples average, at wholesale, $2.25 to $3.15 per "New York barrel," while the Canadian bring $2.91 to $3.87 per "Canadian barrel." The 1894 apple crop of England is exceptionally small, owing to a late frost in the spring. The market for American apples will be good throughout the entire coming winter. It is important that the shippers understand that only choice fruit will pay profit on shipments. It is equally important that the apples be carefully handled and properly packed.

There is also a good demand in England for high-class cider, and there is no reason why the American farmer should not export in this form the apples not properly conditioned for shipment. At the present time English cider is selling at 22 cents per gallon, with a prospect of commanding 25 cents during the greater part of the winter.

EXPORTS OF HORSES.

There is a growing demand in England for American horses. During the first nine months of the year 1894 the English market took two thousand eight hundred and eleven (2,811) American driving horses, at an average value of $139 per head. Last year the average price of those shipped was $230. A sound light draft horse, in good condition, of the size and weight adapted to omnibus work in cities, will generally bring, in Liverpool or London, $150. Nearly all of the shipments of horses thus far from the United States to England have been through English buyers. Arriving in England, the animals are put out to grass, as a rule, for a month at least, and are then sold at auction. Canada has about an equal share with ourselves in the English horse market, although Canadian shipments have the reputation of being somewhat better in quality.

The average price of Canadian geldings during the last nine months has been $160, as against $139 for American. The English understand perfectly well that prices of horses have fallen in the United States on account of the extensive substitution of trolleys and bicycles for horses, and it is generally conceded that a considerable demand for American horses will soon spring up throughout Europe. The great omnibus and tramway companies of London are recruiting their stocks from the United States and Canada very generally at the present time.

POTATOES.

The British acreage in potatoes has not varied materially from half a million acres during many years. In Ireland the acreage has gradually fallen, in the course of fifteen years, from eight hundred and forty-

two thousand (842,000) acres to seven hundred and twenty thousand (720,000) acres. The potato product of the Channel Islands, France, and Belgium amounts to about three million (3,000,000) cwt. every year. But during the year 1894, up to and inclusive of the month of May, a considerable shipment of potatoes was made from England to the United States. When those shipments were made, potatoes were selling in New York for $2.25 per sack of 168 pounds, and the price in England was $7.29 to $12.15 per ton of 2,240 pounds. In October, 1894, potatoes were selling in New York at $1.85 per sack of 168 pounds, while the prices ranged in England at from $14.60 to $17 per ton.

The cost of transportation for potatoes from Great Britain to the United States per ton is about as follows: Drayage to the ship, 60 cents; freight, $3.03; sacks, $1.80. To these figures must be added insurance, duties, and commissions on this side. The duty is put on to protect the "infant industry" of potato growing in the United States. It is supposed to make higher prices for those Americans who raise potatoes, and lower ones for those who eat them. A protective tariff is always depicted by its advocates as a dual blessing to the farmer, so adjusted as to always enhance the things he sells and cheapen the things he buys. However, English potato dealers do not look to the New York market for sales until prices there reach about $2.25 per sack. The potato crop of England this year is so limited that we shall not be able to draw supplies from there, even at higher prices than were obtained last year.

THE ASSISTANT SECRETARYSHIP.

On January 1, 1894, the Hon. Edwin Willits retired from the office of Assistant Secretary of the Department of Agriculture. He remained, by request, up to that date, so that he might complete satisfactorily his arduous duties in connection with the Government's exhibit at the World's Fair. The sense of obligation which the Secretary is pleased to cherish for Mr. Willits, because of his many good services to the Department, is hereby very frankly acknowledged, and a sincere admiration for his rugged honesty, industry, and vigilance, as an official and efficient friend of agriculture during his entire connection with this Administration, is unconcealed.

On the same date, Dr. Charles W. Dabney, jr., president of the University of Tennessee—who had previously been selected by the President and confirmed by the Senate as Assistant Secretary of Agriculture—entered upon the discharge of his duties. During many years this gentleman had been prominently and intimately identified with agricultural education. He had especially prepared himself in that line of study by severe application in the laboratories of this country and in Germany. His experience as a State chemist, as director of an agricultural experiment station in North Carolina, and as president of the University of Tennessee, brought him to his present

position peculiarly well equipped for the discharge of its responsible duties. Therefore, on the 2d day of January, 1894, the Secretary of Agriculture issued a special order wholly revising the duties of the Assistant Secretary. That order assigned to him the entire direction of all the scientific divisions, and likewise of the Office of Experiment Stations, of the Office of Irrigation Inquiry, of the Office of Fiber Investigation, and of the Museum. Himself a scientist, Dr. Dabney has discharged the duty of supervising the expenditures and controlling the direction of scientific research, operations, and policy with admirable judgment and skill.

The application of science to agriculture, under his management, is becoming, through practical bulletins published by the Department and other popular means, more generally appreciated, understood, and approved.

During the year the Department has entered upon two new lines of very important investigation. The first of these relates to grasses and forage plants.

AGROSTOLOGY.

The forage interests of the United States are vast in value. Seventy million (70,000,000) tons of hay are cut and cured each summer. This crop is taken from fifty million (50,000,000) acres of land. Each year's hay crop is estimated to be worth six hundred millions of dollars ($600,000,000). No accurate means have been found for ascertaining the cash value of grasses upon pasture and other lands that are grazed. It is known, however, that those lands support and fatten vast herds of cattle, sheep, and horses. In 1890 such ranges in the United States fed fourteen million fifty-nine thousand and thirty (14,059,030) head of domestic animals. As these millions of animals subsist largely upon native grasses and other forage plants, the magnitude of these figures elucidates the vital necessity of securing, if possible, new and better grasses and forage plants in this country. Therefore the Department of Agriculture has undertaken the development of a Division of Agrostology. The gentleman in charge of this new line of investigation, Prof. F. Lamson-Scribner, has a national reputation. His appointment was made upon the recommendation of many of the best botanists in the several universities and colleges of the United States.

At present agrostology is merely an agency in the Division of Botany. It is the duty of the expert in charge of this agency to study grasses and forage plants in general and to instruct and familiarize the people of this country, through bulletins and leaflets, with regard to the conservation of the native grasses of the continent, and to teach them how to introduce from foreign countries such improved and useful forage plants as may be found adaptable and profitable in the United States. It will be his especial and specific duty to prepare and publish a work on "the forage plants of the United States," and subsequently a more

elaborate publication, Handbook of Grasses of the United States. This will contain descriptions and illustrations of all the known grasses of this country.

Through the Department of State the Secretary of Agriculture has secured the assistance of all the consular agents of the United States in collecting at their several stations or posts of duty any seeds of forage plants. These specimens and seeds are forwarded directly to this Department and submitted to Professor Scribner for examination and testing. Thus it is proposed to search the whole civilized globe for grasses and forage plants which may be of value to the people in each section of the United States. It is hoped that in this way the quantity per acre of the hay crop of this country may be very materially increased and its quality improved. If, however, the hay production per acre in the United States is, as a result of this effort in behalf of agrostology, raised only 1 per cent, it is equal to an increase of six millions of dollars per year in the value of this single farm product. Professor Scribner's investigations have already reached such proportions, and they promise to become of such inestimable value to the farmers of the United States, that it is proposed to create a new division in this Department, as provided in the estimates herewith submitted, to be called "The Division of Agrostology."

AGRICULTURAL SOILS AND CROP PRODUCTION.

The second new line of investigation relates to agricultural soils and crop production. Such soils have long presented a problem unsolved by chemical analysis. It has been known for some time that the peculiarly valuable characteristics of different agricultural soils are often due to some other cause or causes than the chemical composition. Climatic conditions are potent in their influences as to the general distribution of plants, but they alone do not explain why one soil is well adapted to one variety of crop, while the soil in an adjacent field, receiving the same amount of rainfall and heat, is wholly unadapted to it, while perfectly adapted to an entirely different crop requiring an altogether different nutrition.

Records of climatic conditions generally end at the surface of the earth. But the farmer's interests are equally connected and concerned with the climatic conditions within the soil and below the surface of the ground.

The amount of sand, silt, clay, and organic matter contained in soils so modifies the atmospheric conditions that different soils maintain very different degrees of moisture and temperature for plant life. Different varieties of plants require different degrees of moisture and heat for their best development. Thus each class finds the conditions best adapted to its peculiar nature in different kinds of soil. Wheat requires a low temperature. Corn requires a relatively high tempera-

ture. Celery and rice develop best in moist soils. Sweet potatoes and peanuts require a comparatively dry, sandy soil.

Deeply tilled soils provide a large reservoir for the rainfall. The deeper the soil is stirred and cultivated, the larger the reservoir. The texture of the soil—that is, the relative amount of sand, silt, clay, and organic matter which it contains, and the way in which these constituent grains are arranged—determines the amount of water which the soil may retain from rains. Sandy soils retain comparatively little water, because they afford little resistance to percolation of the rainfall. Through them the water leaches down beyond the reach of vegetation, and is lost to plants. Such soils are naturally adapted to the forcing of early "truck" and vegetables, and to such plants as are grown for fine texture and bright-colored leaf development.

Soils having a great amount of clay in their composition offer great resistance to the rainfall. The movement of moisture downward through such soils is exceedingly slow, and thus an abundant humidity is generally retained; this adapts them to the growth of wheat and pasture grasses that need an abundant supply of water for their growth. On such soils tobacco also grows strongly, throwing out heavy leaves which contain a great amount of oil and gum, developing a character of tobacco adapted to an entirely different purpose from that grown from the same seed in lighter soils.

Considerations like these led this year to the establishment of a division in the Weather Bureau for the study of meteorology in its relation to soils. Prof. Milton Whitney, who had previously been in the service of the Department as a special agent engaged upon these investigations and had made a marked reputation by his careful and original work, was appointed chief of this division.

Observations have been made during the past season on the conditions of moisture and heat in the typical soils of the "truck" area of the Atlantic seaboard and in several of the soil areas adapted to the different types of tobacco, and likewise in the soils of the arid regions of the West.

These observations have shown the cause of the peculiar value of "truck" lands. They have indicated also large breadths of land similar to them which are at present practically abandoned, although well adapted to the important and oftentimes very lucrative industry of raising early vegetables for the markets of our great cities. Investigations have shown the reason for the differences in the type of tobacco grown in several of the most important tobacco regions. They have explained why certain types of land in the several regions are not adapted to the varieties of tobacco demanded by the present domestic and foreign markets. They have demonstrated this, and also suggested how the conditions of these lands may be changed to render them productive of a demanded grade of tobacco.

From the careful examination thus far made of the soils of the

so-called arid regions of Kansas, Nebraska, and Colorado, Professor Whitney is convinced that, with their present climate, and with improved methods of thorough preparation and deep cultivation, and with a careful selection and modification and rotation of crops, they may be vastly improved in the certainty and constancy of their agricultural productiveness. Professor Whitney does not claim, however, that deep subsoiling alone can wholly obviate the necessity of irrigation, but he impresses the fact that irrigation is always expensive, and that there are vast areas of arid lands which can never be irrigated nor profitably farmed under existing methods.

The time is not remote when in all the arid and subarid regions of the Northwest deep subsoil tillage will be regarded as the only probable certain assurance against the loss of crops in long-continued drought. The farmers in these regions must soon come to understand that the deeper, in plowing, the soil and subsoil is stirred, with subsequent deep tillage of corn or root crops during the summer, the greater the capacity for the storage of the rainfall and the less the liability of crop failure. Especially will this be demonstrated in the soils and subsoils of Kansas, Nebraska, and the Dakotas, where there is so much of silt and so little of sand in the lands.

When the conditions essential to the proper development of particular kinds of crops are perfectly understood and established, these investigations will supply the basis for a more intelligent use of water. It is now the intention of the United States Department of Agriculture to have the texture and physical conditions of the principal agricultural soils of the American Union thoroughly examined. Thus it will establish among the people the knowledge of the necessary conditions for the maintenance of crops. When the conditions in these typical soils are understood, they will be the basis for comparison with other soils. Such comparison will show what class of crops each soil is fitted for and how soil conditions may be changed to adapt it to any particular crop for which the general climatic conditions seem favorable.

As a basis for this work, a vast amount of material, consisting of nearly two thousand samples of soils, which have been collected with skill and judgment from all parts of the United States, is in possession of the Department.

In consideration of the vast importance of this work, the Secretary of Agriculture recommends that this division be taken out of the Weather Bureau and established as an independent division in this Department. Estimates have been submitted in accordance with this plan.

WEATHER BUREAU.

The administration of the Weather Bureau during the fiscal year ending June 30, 1894, cost fourteen (14) per cent less than the appropriation made for that period of time. The financial history of the

Weather Bureau service is clearly set forth in the appended tabulated statement, which begins with 1882 and closes with 1894, as follows:

Fiscal year ending June 30—	Amount appropriated.	Amount expended.	Deficiency.	Amount returned to Treasury.
1882	$988, 615. 80	$988, 615. 80		
1883	993, 520. 00	993, 520. 00		
1884	958, 034. 57	984, 451. 30	$26, 416. 73	
1885	954, 517. 88	966, 076. 44	11, 558. 56	
1886	955, 740. 80	960, 812. 06	5, 071. 26	
1887	892, 290. 42	902, 042. 67	9, 752. 25	
1888	887, 503. 85	909, 410. 74	21, 906. 89	
1889	845, 896. 27	853, 396. 27	7, 500. 00	
1890	801, 122. 59	810, 622. 59	9, 500. 00	
1891	813, 046. 53	877, 659. 80	64, 613. 27	
1892	889, 753. 50	* 830, 783. 33		* $55, 000. 00
1893	908, 595. 50	* 892, 805. 20		* 15, 000. 00
1894	951, 100. 00	* 812, 711. 60		* 138, 500. 00

* Estimated—accounts not yet permanently closed.

This statement shows that for the year 1894 one hundred and thirty-eight thousand five hundred dollars ($138,500) of the appropriation was covered back into the Treasury—an amount of money aggregating nearly twice as much as all the moneys covered back into the Treasury from that Bureau in the preceding eleven years. It is agreeable to state, also, that the Chief of the Weather Bureau reports the reduction in expenditures to have been made without impairment of the efficiency of the work of the Bureau.

PROMOTIONS.

Important positions in the Weather Bureau were filled during the past year by competitive examinations. Some examinations were freely thrown open to all citizens. Others were only accessible to those in the lower grades of the Weather Bureau whose service ratings were the highest. The results of this competitive system have been exceedingly satisfactory. The introduction of this manner of promoting subordinate officials has been an inspiration to all the Weather Bureau observers to do their very best as forecasters. Examinations have been held for forecast officials. Doubts entertained by many heretofore, as to whether capacity in forecasting might be satisfactorily tested by examinations, have been dispelled. The Weather Bureau itself has conducted the examinations, because this method of securing suitable persons for forecast duty was altogether experimental.

PUBLICATIONS.

During the year the Weather Bureau issued two million six hundred thousand (2,600,000) weather maps outside of Washington, and two hundred and twenty-nine thousand one hundred and twelve (229,112)

within the city's limits. During the same period of time the Bureau issued seventy-one thousand two hundred and sixty-six (71,266) Weather Crop Bulletins.

The observations on the general subject of publications under the head of Division of Records and Editing, regarding gratuitous distribution, apply with peculiar force to the publications of the Bureau.

FORCE AT THE CENTRAL OFFICE.

During the year there was a complete reorganization of the force in the Washington office of the Weather Bureau. In that time fifty-eight (58) persons, whose salaries aggregated fifty-four thousand seven hundred and fifty dollars ($54,750) per annum, were taken from the pay rolls of that office. During the same period forty-five (45) persons, whose salaries amounted to thirty-six thousand seven hundred and seventy dollars ($36,770) per annum, were added to its pay rolls, thus lessening by thirteen (13) the number of persons employed and reducing their annual pay roll seventeen thousand nine hundred and eighty dollars ($17,980). The entire number of persons on the pay rolls of the central office, June 30, 1894, was one hundred and seventy-one (171). Their salaries amounted to one hundred and seventy-eight thousand seven hundred and thirty-one dollars and sixty cents ($178,731.60) per annum.

FORECASTS.

Regular forecasts of weather, wind, and temperature have been made from the 8 a. m. and 8 p. m. observations and furnished to the press associations, telegraph companies, and newspapers throughout the United States. For forty-five (45) separate districts, covering the entire country east of the Rocky Mountains, these forecasts have been made. They are for periods each usually of twenty-four to thirty-six hours, respectively; but for longer periods when conditions seem to indicate such a necessity.

Storm warnings have been wired often to the lake and seacoast stations, and to the director of the Canadian Meteorological Service at Toronto. Warnings of frost to fruit, tobacco, and cotton regions, and warnings of severe local storms, cyclones, cold waves, northers, and dangerous floods have been frequently sent to threatened districts. Such admonitions are issued whenever conditions indicate the necessity for them.

VALUE OF THE WARNINGS.

During the year the Weather Bureau warnings received, as a rule, wide distribution. There were very few disastrous storms of which the people had not been apprised twenty-four to thirty-six hours in advance of their culmination during the last summer. The severe

cyclones of August 25 to 27, and October 12 to 14, 1893, were notably well foretold. The warnings given for those dates italicized the value of the service to agriculture and to commerce.

During the year much inquiry was elicited as to the probable value of the forecast work of the Weather Bureau. It is difficult to estimate with any degree of precision or accuracy the real value of the current work of the Weather Bureau. It, however, affects almost innumerable interests. It varies from day to day in its influence upon, protection over, and conservation of, those multifarious interests. Directors of the State weather service in Ohio and in North Carolina report—the first a saving of two hundred thousand dollars ($200,000) by the warning of January 24, 1894; the latter estimated that during the season two hundred thousand dollars' ($200,000) worth of farm products in his immediate territory was saved from frost by the same means. These estimates are conservative. They only hint at the vast possible value each year of the forecast work and warnings throughout the United States.

In January, 1894, the steamship *Rappahannock* was stranded, and the nearest Weather Bureau observer, at Cape Henry, Va., immediately telegraphed a wrecking company at Norfolk to the effect that unless the stranded steamer lightened up enough to float at high tide on the night of the 24th she would be broken to pieces by a coming storm upon the rocks. The observer's message was communicated to the *Rappahannock* by flag signals. This warning caused the wrecking company to exert themselves to the utmost, and they consequently discharged a sufficient cargo to enable the vessel to float that night at 10.35, and at 12.45 p. m. of the next day, just fourteen hours and ten minutes after the vessel was floated out of danger, because of the Weather Bureau warnings—an intensely severe westerly to northerly gale (which had been forecasted), with freezing temperature, rain, and a heavy sea, set in; and it is generally conceded that had the vessel continued aground until that storm struck her she would have been pounded to pieces and, with her cargo, valued at six hundred thousand dollars ($600,000), proved a total loss.

The September tropical storm of 1894 was forecasted with great accuracy and exactness. Warnings were sent very generally along the Atlantic coast. Because of the admonitions of the Weather Bureau relative to that particular storm one thousand and eighty-nine (1,089) vessels, valued at seventeen million one hundred thousand four hundred and thirteen dollars ($17,100,413), were retained in port. During the October tropical storm of 1894 one thousand two hundred and sixteen (1,216) vessels, valued at nineteen million one hundred and eighty-three thousand five hundred dollars ($19,183,500), were prevented from going out to sea because of the warnings issued by the United States Weather Bureau. The value of the cargoes in all this multitude of ships which were prevented from encountering the tropical storms

of September and October has not been estimated. It is, however, reasonable to presume that the cargoes were worth much more than the ships, and therefore safe to assume that the Weather Bureau warnings for the two months, which kept in port vessels valued in the aggregate at thirty-six million two hundred and eighty-three thousand nine hundred and thirteen dollars ($36,283,913), also preserved from the perils of those most disastrous and far-sweeping storms several million dollars' worth of merchandise, commodities, and other property in transit.

Besides that vast amount of value in materials, many human lives undoubtedly were preserved from jeopardy and death. The records of those vessels which disregarded the warnings of the Weather Bureau in those two storms show that they suffered severely or were utterly destroyed. The owners of the vessels remaining in port because of the Weather Bureau admonitions plainly say that but for those warnings they might have been lost.

It is not practicable to estimate the value of the warnings to agriculture and inland commerce up to this time. But data are being collected by the Weather Bureau which hereafter may be of great service in elucidating the value of its warnings to farmers shipping perishable fruit and root crops in the autumn and spring, as well as to those middlemen who handle such products.

Facts and figures have been quoted sufficiently in the foregoing to prove that the Weather Bureau, when it is properly and efficiently administered, may save to the American people, by its forecasts and warnings, many millions of dollars each year. And as the utmost expenditure for the maintenance of this Bureau at this time is less than one million of dollars annually, the investment is apparently a paying one for all the people. This outlay of money may therefore come properly within the functions of the Government, because it is in the line of protection to property and life.

By recent arrangement with the Postmaster-General, the warnings have been extended by the Post-Office Department to 3,608 more distributing points east of the Rocky Mountains, and thus a greatly increased number received warnings of the tropical storms of September and October above mentioned. The actual saving of property from jeopardy by the admonition of those two months is beyond computation.

The extracts from reports of observers concerning the value of the forecasts and warnings received from the Weather Bureau in connection with the September and October storms of 1894 will be published in the full report of the Weather Bureau Service over the signature of that eminent forecaster, Maj. H. H. C. Dunwoody, in his transmittal of statements to the Chief of the Weather Bureau, showing the forecast work of his division in regard to the prenamed storms.

THE WEST INDIES CYCLONE SERVICE.

This service is continued from July 15 to October 15 each year. Reports are rendered by telegraph and mail from Santiago, Santo Domingo, St. Thomas, and Kingston. At all these points the United States Weather Bureau maintains paid observers. During the hurricane season observations are taken twice each day. They are wired to the United States observer at Key West whenever an unusual meteorological perturbation occurs. All approaching storms are also heralded from the West Indies stations. Voluntary telegraphic reports are received by our observers at Jupiter and Key West, respectively. When of interest they are telegraphed to Washington also from Nassau, New Providence, the Bahama Islands, and Havana. This work is carried on by the cooperation of the governor of the Bahama Islands and the superintendent of the central office of the Meteorological Marine Service at Antilles, Havana.

The attempt has been made by personal interview and correspondence to secure the voluntary cooperation of the Rev. Lorenzo Gangoite, S. J., of Belen College, Havana, and members of the Jesuit Order in Balize, British Honduras, in rendering reports of hurricanes to the United States Weather Bureau. So far the Bureau is much indebted to the Rev. J. T. Hedrick, S. J., of Georgetown College, Washington, D. C., for kind offices in this connection. The commercial importance and great need of reports from Yucatan can not well be overestimated.

TELEGRAPH SERVICE.

The service rendered the Weather Bureau by telegraph companies during the year has been reasonably prompt and generally efficient. The best record of telegraphy in this service was made on the morning of April 6, 1894, when all reports due in Washington at the central office over circuits and by special message were received by 9 a. m., that is, just fifty-four minutes after the time of filing. Not a single report was missing. These reports, be it remembered, embraced observations made at 126 stations. They covered the continent from the British Possessions to the Gulf. They reached from the Atlantic to the Pacific.

During the year a reduction in the cost of the regular "circuit" business of about 15 per cent was effected. This was accomplished by revising and reforming contracts of the preceding year. The total expense for telegraphing (May and June estimated) was one hundred and forty-six thousand one hundred and forty-seven dollars and forty-eight cents ($146,147.48), that is, forty-three thousand eight hundred and fifty-two dollars and fifty-two cents ($43,852.52) less than the allotment. That is a saving of twelve thousand and fifty-two dollars and sixty-six cents ($12,052.66) by reason of reduced telegraph rates. Furthermore, by readjustment of the rates for local forecast and

cotton-region messages an additional saving of about four thousand dollars ($4,000) will result to the Bureau during the current year.

Public appreciation of the warnings of the Weather Bureau and the growing importance attached to their value are very well illustrated in a recent suit against the Pennsylvania Railroad Company for the value of a canal boat wrecked during the storm of August 24 and 25, 1894. The lost boat broke loose from a Pennsylvania Railroad Company tug, by which it was being towed to South Amboy, N. J. In the progress of the trial Sergeant Dunn, the Weather Bureau observer at New York City, testified that he had warned the public, including the Pennsylvania Railroad Company officials, of the approaching storm from Cape Hatteras. The question raised in the case is whether it is a legal duty of those having water craft in their charge to respect Weather Bureau warnings. The decision of the court is awaited with intense curiosity, because it involves, to a certain extent, the value of Weather Bureau warnings. It all indicates that in the near future marine insurance may contain, in every policy, a proviso by which the insurance will become inoperative and void in case of loss by a storm against which the Weather Bureau shall have sent out timely warnings.

BUREAU OF ANIMAL INDUSTRY.

The most effective and valuable work rendered by the Bureau of Animal Industry to the commercial interests of the country during the past fiscal year has been in the inspection of meat for the export and interstate trade. At forty-six (46) abattoirs, situated in seventeen (17) cities, the number of animals inspected has increased from four million eight hundred and eighty-five thousand six hundred and thirty-three (4,885,633) in 1893 to twelve million nine hundred and forty-four thousand and fifty-six (12,944,056) in 1894. The cost of inspection has been reduced from $4\frac{3}{4}$ cents per head in 1893 to $1\frac{3}{4}$ cents per head in 1894.

The ante-mortem and post-mortem inspection of animals intended for human consumption will soon be completely under civil-service rules and altogether in the hands of skilled veterinarians. Hereafter no person can be appointed an inspector except he shall have exhibited to the United States Civil Service Commission his diploma from a reputable veterinary college, and also have submitted to and passed a satisfactory examination before that honorable body. Thus all export and interstate meat will have been examined scientifically by an employee of the United States Government, and by him certificated as wholesome and edible. This governmental certification by skilled veterinarians is in fact a guaranty in all European and other markets of the wholesomeness of American meat. Possibly, as a sanitary precaution, it would be well for the United States to demand governmental inspection and chemical analysis of specimens of all wines, brandies, and other bever-

ages which are imported from Europe, at the hands of the governments of those countries whence they are exported. If it is wisdom on the part of foreign nations to demand inspection and certification (for sanitary reasons) by the American Government of its exports to them, and wise for us to comply with that demand, would it not be equally wise (upon sanitary grounds) for the United States to require governmental inspection and certification of all foreign nations for exports into the United States intended for the consumption of its citizens?

The amount of pork microscopically examined for export during the year was thirty-five million four hundred and thirty-seven thousand nine hundred and thirty-seven (35,437,937) pounds. But in the year 1893 it was only twenty million six hundred and seventy-seven thousand four hundred and ten (20,677,410) pounds. In 1894, one million three hundred and seventy-two thousand four hundred and ten (1,372,410) pieces, from as many different carcasses, have been microscopically examined under the direction of this Bureau.

The cost of microscopic inspection has been diminished during the year 1894 from 8¾ cents per carcass or piece, in 1893, to 6½ cents per capita. This indicates a reduction of nearly 25 per cent. The cost of inspecting microscopically the pork sold in Germany and France (no other European countries demand such inspection) by the United States, in the year 1893, was one hundred and seventy-two thousand three hundred and sixty-seven dollars and eight cents ($172,367.08). But during the year 1894 the quantity so inspected was increased fifteen millions (15,000,000) of pounds, and the cost of inspection was in the same twelve months reduced to eighty-eight thousand nine hundred and twenty-two dollars and ten cents ($88,922.10).

During the last half of the fiscal year the United States exported twenty-two million eight hundred and nineteen thousand two hundred and thirty-one (22,819,231) pounds, and the cost of inspection was thirty-six thousand four hundred and eighty-eight dollars and forty-two cents ($36,488.42).

The Secretary of Agriculture recommends that the law providing for the inspection of export and interstate meat be so amended as to compel the owners of the meat inspected to pay the cost of the microscopic inspection. If governmental inspection and certification widens the foreign and interstate markets for the products of any slaughtering and packing establishment, it, by having increased the demand for those products, has enhanced their prices. It is only equitable that those pay for the inspection who are directly pecuniarily benefited thereby.

As long as the Government pays for microscopic meat inspection, many establishments will demand inspection which have neither interstate nor export trade. If the inspection is worth anything at all to killers, packers, and dealers in fresh or cured meats, they should pay for it. As the law exists to-day, any slaughtering establishment, no matter how insignificant, which declares it has or expects to have

foreign trade in meats, has a legal right to demand governmental inspection and certification. It costs individuals nothing. When the killers, packers, and dealers demanding the inspection are compelled by law to pay the cost thereof, only that inspection will be called for which is necessary for the facilitation of foreign trade. No inspection will be asked merely to give employment to microscopists and others, at the expense of the Treasury of the United States. It is temptingly easy to be benevolent and generous at public cost.

The live beef cattle exported and tagged during the year numbered three hundred and sixty-three thousand five hundred and thirty-five (363,535). This is an increase of sixty-nine thousand five hundred and thirty-three (69,533) head, or more than 25 per cent, as compared with the previous year.

In the same time the employees of the Bureau of Animal Industry inspected, also for export, eighty-five thousand eight hundred and nine (85,809) head of sheep.

After the experience of supervising the transportation of export animals for some years, many modifications of the accommodations and conditions for their proper care have been insisted upon and adopted. By these innovations and ameliorations the losses in shipping live cattle have been very much reduced. In 1891 those losses were 1.6 per cent; in 1892 they were 0.75 per cent; in 1893, 0.47 per cent, and in 1894, 0.37 per cent; sheep lost in transportation during the present fiscal year, 1.29 per cent. This latter rate of loss indicates that further modifications of the regulations regarding the shipment of sheep are desirable.

Stock yards inspection is maintained for the purpose of tagging export cattle, and for supervising their shipment to the seaboard and certifying their healthfulness at the time they leave American ports. It is further intended to prevent the dissemination of Texas fever. Southern cattle inspection is reported by the calendar year instead of the fiscal year, in order to include an entire quarantine season, which extends from February 15 to December 1. During 1893 there were inspected and placed in the quarantine pens in various stock yards one million seven hundred and thirty-seven thousand three hundred and eighty (1,737,380) head of cattle. During the same period of time inspectors supervised the cleaning and disinfection of fifty-six thousand four hundred and six (56,406) cars. In Great Britain the inspection of animals received from the United States has been continued for the purpose of learning the condition in which they reach British ports and the amount of losses suffered at sea from diseases with which animals in transit are often affected, and also for the purpose of ascertaining the adequacy of the sanitary regulations and fittings of the vessels engaged in animal transportation.

This thorough inspection, it has been hoped, would result in the revocation of the British restrictions upon the American cattle trade, by

demonstrating that there is no danger, through animals of the United States, of the introduction of contagious diseases into the United Kingdom. More than two years have passed without the development of any pleuro-pneumonia or other diseases in the United States which might be, through our export cattle, made dangerous to the stock interests of Great Britain. But the hoped-for revocation of British restrictions remains unrealized.

The expense of sanitary inspection of cattle shipped to Europe has averaged $10\frac{3}{4}$ cents for each one exported. The cost of inspecting Southern cattle and supervising the disinfection of cars and stock yards averages 2.7 cents per animal.

During the year there were quarantined eight hundred and six (806) head of imported animals. In the same time there were imported from Canada and inspected one hundred and ninety-four (194) head of cattle, two hundred and forty thousand four hundred and twenty-seven (240,427) sheep, thirteen hundred and two (1,302) hogs, and two (2) goats.

The scientific inquiries of the Bureau of Animal Industry have progressed steadily during the year, and much tuberculin and mallein have been furnished to State authorities for use in the ascertainment and treatment of tuberculosis and glanders.

The appropriation to the Bureau of Animal Industry for the year ending June 30, 1894, was eight hundred and fifty thousand dollars ($850,000). The expenditures during the year out of that appropriation aggregate only four hundred and ninety-five thousand four hundred and twenty-nine dollars and twenty-four cents ($495,429.24). This leaves an unexpended balance of three hundred and fifty-four thousand five hundred and seventy dollars and seventy-six cents ($354,570.76).

In the appropriation bill for the current year (1894–95) tuberculosis and sheep scab are specifically mentioned among those diseases which the Secretary of Agriculture is authorized to guard against in such manner as he may think best. Endeavoring to carry out the suggestive provisions of the act above cited, the Department has avoided expending public funds for such purposes as private owners or the respective States ought reasonably to provide for. It is believed to be the duty of the Bureau of Animal Industry to seek, in every possible way, scientific enlightenment, to be disseminated among the agriculturists of the country, so as to lead up to the extermination and suppression of the diseases of domestic animals; but it is not believed that the Department of Agriculture is justified in much other than educational work. The several States of the Union can do the necessary police work in the prevention of the spread of diseases of domestic animals within their own bounds. But very much must be left to the enlightened self-interest of the stock owners themselves.

Quite recently this Department has published the result of its investigations of bovine tuberculosis. These researches will be vigorously continued. Certain herds in the District of Columbia will be thoroughly inspected, and many of the animals which respond to the tuberculin test may be slaughtered, and for them, by the terms of the appropriation act, their owners may be partially remunerated. But there will be only a sufficient number of animals purchased by the Department to intelligently prosecute its scientific work and for purposes of illustration, description, and definition.

THE STERILIZATION OF MILK.

The sterilization of milk suspected of containing the bacilli of tuberculosis has been very thoroughly explained in a leaflet by Dr. D. E. Salmon, the chief of the Bureau. This leaflet was issued July 24, 1894, and given general circulation throughout the country. Pending the investigation of tuberculosis, and in view of the jeopardy to human health and life which some say is constantly evolved therefrom, the sterilization of milk may be made a shield and safeguard in every household.*

OFFICE OF EXPERIMENT STATIONS.

The Office of Experiment Stations, which is a part of the United States Department of Agriculture, has during the past year engaged itself almost wholly in preparing for publication works based upon the reports of Agricultural Experiment Stations and other institutions for agricultural inquiry in the United States and foreign countries. Bulletins, reports, and other publications from such stations have multiplied so rapidly that it is absolutely necessary to brief them in order to give them general circulation. Therefore, in order to reach the American farmers, the aforesaid bulletins and reports have been abstracted, sifted, compiled, and published in convenient form. Twenty-four (24) documents, making over two thousand (2,000) pages, have been issued. Among them is the fifth volume of the Experiment Station Record. It contains abstracts of three hundred and ten (310) reports of American stations, sixty-seven (67) bulletins of this Department, and two hundred and twenty-seven (227) reports of foreign stations and other institutions.

The Handbook of Experiment Station Work is a digest of the published work of the American experiment stations during the past twenty years. There has also been prepared a number of farmers' bulletins, based chiefly upon the work of experiment stations. There is now in process of publication a handbook on the culture and uses of the cotton plant. This will present a scientific and condensed state-

*The further remarks on this subject which occurred in this report are omitted here owing to the full discussion of the same topic from the same point of view in another part of this book.

ment of practical knowledge. It will tend to improve the varieties of the cotton plant and advance the methods of culture and stimulate the production and use of cotton-seed products.

During the year seeds of new and rare varieties of foreign plants and vegetables have been distributed to forty (40) experiment stations and to about three thousand (3,000) farmers selected by those stations for the purpose of making full tests.

The Secretary of Agriculture in his report for 1893 called attention to the fact that the appropriations made for the support of the experiment stations throughout the Union were the only moneys taken out of the National Treasury by act of Congress for which no accounting to Federal authorities was required. The Fifty-third Congress, heeding the suggestion, in making the appropriation for the Department for the present fiscal year provided that—

> The Secretary of Agriculture shall prescribe the form of annual financial statement required by section 3 of said act of March 2, 1887; shall ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of said act, and shall make report thereon to Congress.

That the stations might have the earliest advice as to the intentions of the United States Department of Agriculture with regard to their expenditures, schedules for the financial reports of the experiment stations were prepared and issued to them immediately after the appropriation bill had passed. This new provision of law, construed with the previous legislation on the subject, gives the Secretary of Agriculture ample authority to investigate the character and report upon the expenditures of all these stations. Obeying this law, the Department of Agriculture proposes to make, through its expert agents, systematic examinations of the several stations during each year, for the purpose of acquiring, by personal presence, detailed information necessary to enable the Secretary of Agriculture to make an exhaustive and comprehensively satisfactory report to Congress. It is due to the boards of management of the several stations to state that, with great cordiality, they have, almost unanimously, approved the amendment to the law which provides for this supervision of their expenditures. Many of them declare that it will increase the efficiency of the stations and protect good men from loose charges of the misuse of public funds; and, furthermore, that it will bring the United States Department of Agriculture into closer and more confidential relations with the experiment stations, and that, acting together thus harmoniously and intelligently, the efficiency of their service to the agriculture of the Union will be vastly advanced.

NUTRITION.

Acting upon the recommendations contained in the report of 1893, Congress appropriated ten thousand dollars ($10,000) "to enable the Secretary of Agriculture to investigate and report upon the nutritive

value of the various articles and commodities used for human food, with special suggestion of full, wholesome, and edible rations, less wasteful and more economical than those in common use."

Out of this appropriation money will be used to make analyses of food materials not heretofore analyzed, and for the investigation of the dietaries of the different classes of people in different portions of the country. The relation of food supply and consumption will be elucidated. Inquiries as to the best means of improving the methods of investigations along these lines will likewise be diligently made. A large amount of preliminary work has been accomplished during the year, the results of investigations thus far made in this country and elsewhere have been correlated, and a bulletin containing a résumé of these matters is already in press.

The health of all depends largely upon the adaptability of the food consumed. The capacity for work in each human being rests upon the same foundation. But the most intelligent know very little as to the real composition of their daily food. The kinds or amounts of nutritive material contained in it and its value are generally matters of guesswork, if thought of at all. The cost of this ignorance is loss of health and waste of money. Unfortunately it is the poor who suffer most from the unwise purchase and improper use of food. It is too often true that the poor man's money is the worst spent in the market, and too often true that the poor man's food is the worst cooked and served at home. In this matter of nutrition is a verification of the Scriptural passage: "To him that hath shall be given, and from him that hath not shall be taken even that which he hath."

From the hygienic standpoint also the demand for increased knowledge of this kind is imperative. A large part of the diseases formerly attributed to old age is due, in greater or less degree, to errors in diet.

Earnest and intelligent investigation of food and the relative nutritive value of various kinds is needed, and the facts found in these researches should be widely scattered among the people of the United States. And it must not be forgotten that here, as elsewhere, the knowledge which has the most immediate, practical value must be based upon research of the highest scientific order.

Cooperation by the agricultural colleges and experiment stations will be sought in these investigations. To Mr. Edward Atkinson, economist and publicist, of Boston, Mass., and to the distinguished physiological chemist, Prof. W. O. Atwater, of the Wesleyan University at Middletown, Conn., the Department and the American people are very much indebted because of their earnest, intelligent researches in, and unselfish devotion to, the science of nutrients and nutrition.

If such investigations are considered by such men worthy of their diligent and untiring pursuit, how much more ought the same subjects to be of interest to the teachers and pupils of the schools of this Republic! As civilization advances, the time approaches when the proper

use of nutrients and the correct nutrition of the human body will be regarded as indispensable to the proper education of every American boy or girl.

A farmers' bulletin, containing an elementary discussion of the nutritive value and pecuniary economy of foods is now nearly ready for distribution. Fully one-half of all the money earned by the wage earners of the civilized world is expended by them for food. In this paper the first lessons are given in the proper selection and economy in the use of food materials. But an economy of food is not the only thing desirable. More important than this is the question of cooking food in such manner as will in the greatest degree promote the public health.

The following extract from the farmers' bulletin on foods, above referred to, was given to the newspapers of the United States some weeks since. It contributed to a discussion of the discrepancy between the price of flour *to* the baker and the price of bread *from* the baker, which has made better loaves and more nutriment for less money in many cities throughout the country. All eat bread—they have been benefited. Relatively few make bread, and they have not been unjustly treated:

THE COST OF BREAD.

The chief difference in the composition of flour and bread is the proportions of water, which makes about one-eighth the weight of flour and one-third that of the bread. The average composition of wheat flour and the bakers' bread made from it is about as follows:

Comparison of flour and bread.

	Water.	Nutrients.					Fuel value of one pound.
		Total.	Protein.	Fats.	Carbohydrates.	Mineral matters.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Wheat flour	12	88	11	1	75	1	2,000
Bakers' bread	32	68	9	2	56	1	1,300

In making the bread a little butter or lard, salt, and yeast, and considerable water, either by itself or in milk, are added to the flour. The yeast causes carbohydrates (sugar, etc.) to ferment, yielding alcohol and carbonic acid in the form of gas, which makes the dough porous. In the baking the alcohol is changed to vapor and the carbonic acid is expanded, making the bread still more porous, and both are mostly driven off. Part of the water escapes with them. The amount of sugar and other carbohydrates lost by the fermentation is not very large, generally from 1½ to 2 per cent of the weight of the flour used. With the increase in the proportion of water in the bread as compared with the flour the proportion of nutrients is diminished, but the addition of shortening and salts brings up the fat and minerals in the bread so that the proportions are larger than in the flour.

In practice 100 pounds of flour will make from 133 to 137 pounds of bread, an average being about 136 pounds.

Flour, such as is used by bakers, is now purchased in the Eastern States at not over $4 per barrel. This would make the cost of the flour in a pound of bread about 1½

cents. Allowing one-half cent for the shortening and salt, which is certainly very liberal, the materials for a pound of bread would cost not more than 2 cents. Of course there should be added to this the cost of labor, rent, interest on investment, expense of selling, etc., to make the actual cost to the baker.

Very few accurate weighings and analyses of bakers' bread have been made in this country, so far as I am aware, but the above statements represent the facts as nearly as I have been able to obtain them.

The average weight of a number of specimens of 10-cent loaves purchased in Middletown, Conn., was 1¼ pounds. This makes the price to the consumer 8 cents per pound. The price of bread and the size of the loaf are practically the same now as when the flour cost twice as much.

The cost of bakers' bread is a comparatively small matter to the person who only buys a loaf now and then, but in the Eastern States and in the larger towns throughout the country many people, and especially those with moderate incomes and the poor, buy their bread of the baker. Six cents a pound, or even half that amount, for the manufacture and distribution seems a very large amount.

In the large cities competition has made bread much cheaper, but even there the difference between the cost of bread to the well-to-do family who bake it themselves and to the family of the poor man who buy it of the baker is unfortunately large.

DIVISION OF ENTOMOLOGY.

On April 26, 1894, Prof. C. V. Riley, for many years the chief of the Division of Entomology of the United States Department of Agriculture, submitted his resignation. That communication states: "This action, which I have for some time contemplated, is taken without suggestion from or consultation with you (the Secretary of Agriculture) or anyone else, but purely for the reasons mentioned." Among those reasons is stated "a due regard for the wishes of family and for health."

The services of Professor Riley to American entomology, extending over nearly a generation, are fully known and justly appreciated in the United States and in foreign lands. His resignation for the reasons which he cogently stated compelled its own acceptance and released him from arduous and taxing duties. Mr. L. O. Howard, who had during nearly the entire incumbency of Professor Riley been the assistant entomologist, and who had already earned a reputation as a scientific man and an economic entomologist, was promoted immediately to the position of chief of the division, and then, by order of the President of the United States, the division was classified into the civil service, so as to include both the chief and assistant chief.

In the year 1894 diligent attention has been paid to ascertaining the exact localities in the several Eastern States where the San Jose or pernicious scale of California is alleged to have made its appearance. The method of the dissemination of this pest has been found, and the nurserymen concerned in its spread have been induced to make strenuous efforts for its destruction.

Insects injurious to stored grains have also been under continuous investigation, and a full report thereupon, with results of remedial experimentation, will soon be given to the public.

Investigations of the chinch bug have been extended in certain Western States, in cooperation with the Department, and facts of practical value, bearing upon the relations of agricultural methods and climate to the propagation of the chinch bug, have been ascertained.

The insect enemies of the orange and other citrus fruits have been diligently studied, and much valuable material collected for an additional report upon this subject. In harmony with the provisions of the appropriation bill, cotton insects have been the subject of much research. Inquiries were made in the States of Texas, Louisiana, Mississippi, and Alabama, where results of practical value have been reached.

A new and very active enemy of the cotton crop has been discovered recently in Texas, where it was introduced from Mexico. It is in the shape of a weevil, which bores into the bolls. The study of this insect has been begun. A special agent was sent to the agricultural sections of Mexico recently opened up by railways, who has forwarded to the Division of Entomology many interesting specimens and many valuable data which will serve to familiarize the people with other injurious insects which are liable to be imported from Mexico to the United States.

The experimental work against predaceous and destructive insects has been continued, mainly in the line of testing new machinery and in determining the effects of insecticide mixtures upon the foliage of plants at different seasons, and in determining the usefulness of these insecticides against the new peach scale and the San Jose or pernicious scale of fruit trees above referred to. The publication of a series of leaflets or circulars upon insects especially dangerous to horticulture has been commenced. A manual of bee culture is completed, and one bulletin has been contributed to the series of the division and another to the series of the farmers' bulletins.

DIVISION OF VEGETABLE PATHOLOGY.

The diligent study of the diseases of cereal crops and fruits has been continued by this division during the entire year. Recognizing the vast value of the cereal crops produced in this country, and the immense losses accruing to them because of the attacks of certain diseases, particularly rusts and smuts, an expert investigator was appointed early in the year to take charge of this particular line of inquiry.

In the laboratory of the division at Washington, pear blight, diseases affecting the melons of the South, diseases of cereals, and diseases of fruits of the Pacific Coast and of Florida have been investigated. It has been ascertained that a simple and inexpensive treatment used early in the spring will almost completely hold in check a disease of the leaves of the peach tree which has recently damaged fruit growers many thousands of dollars. The remedy has been tested among the

peach orchards of California and the eastern portion of the United States and has proved highly efficacious. Several other diseases of plants and fruit trees are now under investigation with excellent probabilities of discovering a successful remedy. A branch station of this division in Florida is particularly devoting itself to the study of the diseases of citrus fruits and other subtropical plants.

DIVISION OF ORNITHOLOGY AND MAMMALOGY.

The work of this division divides itself into two attractive subjects. The first is the geographic distribution of animals, and the second the study of injurious and useful birds and mammals. Under the first head enough data have now been collected to finally solve the problem of temperature control of the geographic distribution in North America of animals and plants. Their laws of distribution have been formulated, and the result of the investigation will be published in a few months. The study of life zones has extended over large areas in the West. The field work has covered twenty-five (25) States and Territories west of the Mississippi River, and also embraced Pennsylvania and three of the Southern States.

Two groups of mammals very injurious to agriculture, the California jack rabbit and the pocket gopher of the plains and the Mississippi Valley, have received attention during the year. An exhaustive study has been made of the pocket gopher, the results of which will appear in a popular bulletin on his food habits, his injury to crops, and the methods of extermination.

During the inquiry into the food of birds and mammals, three thousand four hundred and twenty (3,420) stomachs of birds were added to the collection, and fourteen hundred and forty (1,440) of them were carefully examined. The stomachs of many mammals were dissected in the laboratory and in the field. A report on the food habits of the kingbird, with special reference to its habits relating to agriculture and horticulture, has been prepared. There has also been completed a leaflet on the food habits of the woodpecker, and a similar one on the food habits of blackbirds.

Some species of beautifully plumaged and useful birds are being exterminated in the United States to satisfy the barbaric demand for ornithological ornamentation of feminine head wear. By educating the public mind to a better understanding of birds, their interesting habits and uses to man, this division is doing much to prevent this and other similarly cruel and senseless practices which, if not arrested, will result in the total destruction of many of our most beautiful and useful American birds.

The eminent scientist at the head of this division, Dr. C. Hart Merriam, and his capable assistant have been, by order of the President, placed in the classified service.

DIVISION OF BOTANY.

During 1894 a great amount of agitation and some trepidation has existed in certain Northwestern States relative to the Russian thistle and its possible detrimental and universal dissemination throughout the Northwest. The Division of Botany, therefore, made a special effort to systematically collect information as to this newly arrived emigrant weed and to provide methods for its speedy repressment and eradication. One result of this inquiry is that the seeds of new grasses and forage plants from abroad will be hereafter, for the public protection, very carefully inspected as to their freedom from weed seeds. If possible, it might be well to require certification as to freedom from weed seeds and absolute purity and vitality of all seeds imported into the United States. A laboratory has been equipped and a special assistant detailed to give his entire time to the study of seeds with regard to their purity, vitality, and improvement.

The census of 1890 shows the value of farms in the United States which are entirely devoted to seed growing to be over eighteen millions of dollars ($18,000,000). The export of clover seed alone during the year ending June 30, 1894, is estimated at four million five hundred and forty thousand dollars ($4,540,000). The export of American seeds may be vastly increased by exalting the standard of purity and germinating vitality and giving all other peoples the same guaranty that we ask of them. The same course will increase the domestic use of American-grown seed. When information as to its high quality has been diffused, this course will vastly widen the world markets for American seed and so enhance their value by giving increasing demand everywhere.

DIVISION OF FORESTRY.

The greater part of the appropriation for the Division of Forestry has been expended during the present year in investigating the strength of different timber woods and the conditions that influence their quality. The importance of such an inquiry was pointed out in the Report of the Secretary of Agriculture for 1893. Attention was also called to the unqualified commendations which had been bestowed upon this work not only in the United States but in foreign countries. The full value of the investigation will not be apparent until it has been carried to a successful termination, when the accumulated data will be carefully collated, with the intent of discovering the laws which give different degrees of strength to different varieties of timber. A knowledge of such laws will make the everyday use of timber in building much safer and more satisfactory than it has been. The financial and economic value of these timber examinations can hardly be estimated at the present moment.

The practice of "boxing" pine trees for turpentine, it has been discovered, does not decrease the strength of the lumber. This discovery alone, it is stated, will add two millions of dollars to the value of the

pineries of the Southern States which are being "bled" for turpentine. It is further established that the long-leaf pine of the South is generally far stronger than heretofore admitted, and, therefore, for structures like bridges, trestles, and rooftrees made of this timber it is practicable to effect a saving of 25 per cent of material without reducing the factor of safety. This saving applies to about two million M. feet of longleaf pine timber annually used for such purposes, and the present money value of that saving of long-leaf pine lumber can be calculated at six millions of dollars ($6,000,000). These facts may render possible the extension of the time in which our forest supplies of this most valuable timber must be exhausted. This line of work, which establishes the true value of our varieties of timber, should be pushed to a conclusion as rapidly as possible. Therefore it has been recommended that Senate bill No. 313, making a special appropriation of forty thousand dollars ($40,000) for the completion of this work, be passed whenever the people seem to demand it and the condition of the public Treasury may permit such an expenditure.

Inquiry into the rate of growth and production of the most valuable lumber trees is needed in order to properly estimate the profit that may be derived from forest management. Only the white pine and the black spruce have so far been partly examined. But the information obtained is so valuable that it makes more apparent than ever the necessity of similar investigations upon other timber trees. Inquiries have been made, and are in progress, as to the principles and effectiveness of dry kilns for lumber, and also as to the increase in the use of metal for railroad ties and other processes of economy in the use of wood for railroad construction.

Popular instruction as to the disastrous results upon adjacent agricultural valleys of the denudation of hills and mountains should be given in every schoolhouse in the Union. Professor Rothrock, of Pennsylvania, and Dr. Fernow, the chief of the Division of Forestry of the United States Department of Agriculture, have shown themselves efficient teachers and workers in this regard. The deforestation of the American Continent will practically be an accomplished fact within another century unless systematic and intelligent reafforestation be speedily inaugurated.

DIVISION OF CHEMISTRY.

The Division of Chemistry, in harmony with the provisions of the appropriation act, has during the past year devoted itself to the investigation of the adulteration of foods, drugs, and liquors, and to the prosecution of experiments in sugar production. Examinations for the usual adulterations have been made of large numbers of specimens of meals, flours, and breads; but in no instance has there been found an adulteration of American flour with terra alba or any other material. It is gratifying to know withal that while this sort of adulteration is

practiced largely in foreign countries, it has not obtained foothold in the United States. The only deceptions in the flour trade have been found in the substitution of cheaper grades for dearer ones. In bread the chief adulterant found has been alum. That substance is added for the purpose of whitening the loaf.

Wines have been examined very thoroughly; especially have adulterants been sought for in the coloring matter used. It is impossible to tell by chemical analysis whether any given amount of alcohol found in wines is natural or artificial. The Division of Chemistry has ascertained that the pure wines of the United States and the pure wines produced in Europe are not very dissimilar in many cases. Where there are differences, they have been carefully determined and defined.

The chemical examinations of the typical soils of the United States have been commenced, and a series of pot experiments have been begun, having for their object the practical test of the several methods of analysis heretofore adopted and the actual powers of plants to assimilate different kinds of food in the soil. It is sought in this way to learn approximately the available plant food in each type of soil. In conjunction with this, a thorough study of the nitrifying organisms of the soils has also been commenced. In addition to the above work, numerous inquiries as to the methods of analysis have been carried out, and a great number of miscellaneous samples have been analyzed.

DIVISION OF POMOLOGY.

During the year Mr. S. B. Heiges, of Pennsylvania, a horticulturist of long experience and of practical skill, was made chief of the division, and it is to-day in better working order than ever before since its creation. By order of the President it has been placed wholly in the classified civil service, from the chief and assistant chief down to the messengers.

The division is principally engaged in correspondence with fruit growers; in critical examination and comparison of specimen fruits received from them for identification, description, and illustration of such specimens as may seem worthy of record and propagation. All new and improved varieties of this sort are modeled and colored.

During the year close attention has been given to the investigation of the varieties of the apple. Notwithstanding the almost total failure of the crop, some two hundred (200) specimens of new or little-known varieties of apples—some of which promise to be very valuable—have been received. Beside these many old varieties which had been catalogued and planted as new have been identified as to their origin and character.

The damaging frosts of the last week in March were made the subject of investigation during the month of April, and the results were published in a special circular with the report of the Statistician for May. Important facts were developed in the course of this inquest which will

be of great value to peach growers. Noticeable among them is the fact that certain groups or families of the Persian race of peaches bloom later than others in the South, and they are therefore less likely to have their fruit cut off by frosts. This discovery is of great value, and estimated to be worth, in dollars and cents, many times the expense of the investigation. Numerous scions and plants of promising varieties have been experimentally planted during the year.

Among the principal importations by the Division of Pomology are collections of fig cuttings from England and citron cuttings from Corsica.

DIVISION OF ACCOUNTS.

Congress appropriated to the United States Department of Agriculture for the year ending June 30, 1894, exclusive of the appropriation of seven hundred and twenty thousand dollars ($720,000) for agricultural experiment stations, $2,603,500. Of this amount one million seven hundred and ninety thousand five hundred and thirty dollars and seventy cents ($1,790,530.70) were disbursed prior to July 1, 1894. In addition to this sum there remained at that date unpaid bills aggregating $200,000. The payment of these will make the total expenditures for the fiscal year 1894 $1,990,530.70. In other words, when the accounts of the Department of Agriculture for the fiscal year ending June 30, 1894, shall have been finally adjusted there will be covered back $600,000 into the United States Treasury, or about 23 per cent of the entire appropriation.

For the last fiscal year 31 specific appropriations were made, and 15 subappropriations which required separate and distinct accounts.

During the year 11,863 accounts were received, audited, and paid. They included the supplemental accounts of 1893, which amounted to $1,967,842.79. Ninety-three requisitions were drawn on the United States Treasury in liquidation of those accounts, aggregating $2,014,809.95. Those requisitions were in settlement of 19,100 checks, exclusive of about $450,000 paid in currency over the counter.

During the year 59 separate amounts were received from various sources from the sale of condemned Government property. That and other similarly derived moneys were deposited in the United States Treasury to the credit of "Miscellaneous receipts," as provided by law. They aggregated $7,135.

During the twelve months ending June 30, 1894, the expenditures chargeable to the appropriations for that fiscal year were less by $386,364.83 than the expenditures during the twelve months ending June 30, 1893, chargeable to the appropriations for that year—an average monthly reduction of $32,197.07. Attention is called to the statement of the Annual Report of the Department of Agriculture submitted on the 20th of November, 1893, in which the hope is expressed that a saving may be made of 12 per cent, and to the fact that the present report justifies that hope and verifies all that has been claimed as to economy in the present management.

The statements of the several divisions of the Department show that efficiency has not been sacrificed to economy, because in each division it is observable that more and better work has been accomplished during the last twelve months than during any previous twelve months of their existence.

The total appropriations for 1894-95 are less by $104,476.94 than those for the year 1893-94. And this decrease occurs notwithstanding a new appropriation of $10,000 for nutrition and the fact that the seed fund included $30,000 for farmers' bulletins. The estimates for 1896 are less by $98,693.06 than the appropriation for the current year.

The expenses of the Department of Agriculture from July 1 to October 31, 1894, were less by $9,418.76 than during the parallel period of last year; and by $78,852.41 than during the period from July 1 to October 31, 1892, thus realizing the hope expressed in the report of the Secretary for 1893 that the reduction then referred to would be made permanent.

There were upon the pay rolls of the Department, in the city of Washington, on March 1, 1893, 750 persons, with salaries aggregating $54,764.82 per month.

On March 1, 1894, the rolls showed 622 names, with salaries amounting to $49,085.66 per month.

On November 1, 1894, there were 559 employees, with salaries aggregating $45,557.74 per month; a reduction of 191 in the number of employees between March 1, 1893, and November 1, 1894, and a saving in the amount of salaries of $9,207.08 per month.

Comparative statement showing amount of appropriations for the Department of Agriculture for the fiscal year ending June 30, 1895, and amount of estimates submitted by the Secretary of Agriculture for the fiscal ending June 30, 1896.

	Appropriation 1895.	Estimate for 1896.	Increase.	Decrease.
Office of the Secretary	$91,140.00	$94,140.00	$3,000.00	
Division of Accounts and Disbursements	17,300.00	17,500.00	200.00	
Division of Statistics	145,360.00	145,160.00		$200.00
Division of Botany	38,600.00	33,800.00		4,800.00
Division of Entomology	29,800.00	29,500.00		300.00
Division of Ornithology and Mammalogy	27,360.00	27,560.00	200.00	
Division of Pomology	11,300.00	12,500.00	1,200.00	
Division of Microscopy	7,300.00	7,300.00		
Division of Vegetable Physiology and Pathology	26,100.00	26,500.00	400.00	
Division of Chemistry	32,000.00	32,000.00		
Division of Forestry	28,320.00	33,520.00	5,200.00	
Division of Publications (Records and Editing)	8,100.00	8,300.00	200.00	
Division of Illustrations	15,000.00	15,000.00		
Farmers' Bulletins (Division of Seeds)	177,520.00	56,000.00		121,520.00
Document and Folding Room	5,600.00	9,040.00	3,440.00	
Museum	5,400.00	5,400.00		
Library	6,000.00	6,000.00		
Agricultural experiment stations	745,000.00	750,000.00	5,000.00	
Experimental gardens and grounds	32,000.00	28,500.00		3,500.00
Furniture, cases, and repairs	10,000.00	10,000.00		
Postage	5,000.00	2,000.00		3,000.00

Comparative statement showing amount of appropriations, etc.—Continued.

	Appropriation 1895.	Estimate for 1896.	Increase.	Decrease.
Contingent expenses	$25,000.00	$25,000.00		
Investigations with relation to agricultural soils		15,000.00	$15,000.00	
Inquiries relating to public roads	10,000.00	10,000.00		
Experiments in the manufacture of sugar	10,000.00	10,000.00		
Irrigation investigations	6,000.00	8,000.00	2,000.00	
Nutrition investigations	10,000.00	15,000.00	5,000.00	
Investigations, etc., with grasses and forage plants		15,000.00	15,000.00	
Fiber investigations	5,000.00			$5,000.00
Bureau of Animal Industry	800,000.00	800,000.00		
Quarantine stations	12,000.00	12,000.00		
Weather Bureau	876,823.06	860,610.00		16,213.06
Total	3,219,023.06	3,120,330.00	55,840.00	154,533.06
Net decrease				98,693.06

NOTE.—The amount appropriated for the office of the Secretary for the fiscal year 1895, as itemized in the bill passed August 8, 1894, was $94,140; but, by an error in printing, was stated as $91,140.

NOTE.—The amount appropriated for seeds for the fiscal year 1895 was divided as follows: Purchase of seeds, $130,000; farmers' bulletins, $30,000; salaries, $12,120; printing, $5,400.

NOTE.—The amount appropriated for agricultural experiment stations for the fiscal year 1895 includes $720,000 for State experiment stations, over which the Department of Agriculture has no control. This statement also applies to the amount estimated for the fiscal year 1896.

The Department of Agriculture expended for the fiscal year 1892 $2,271,312.72; and out of that sum the total amount expended in scientific research was 46.2 per cent. For the fiscal year 1893 the expenditures were $2,354,809.56, and out of it only 45.6 per cent was expended in the application of science to agriculture. But for the year ending June 30, 1894, out of a total expenditure of $1,990,530.70 (estimated), the Department applied 51.8 to scientific work and investigation.

It is, therefore, very plainly observable that the economies which have been practiced in the administration of the Department have not impaired its capacity for scientific research. Comparing the expenditures for the fiscal years 1893 and 1894, respectively, it is noticeable that the total expenditures for 1894 are $364,278.86 less than the total for 1893. But the per cent of the total amount paid out for scientific work, as distinguished from the administration and general business, is 5.6 per cent more, in proportion to the total expenditures during the year 1894, than it was in 1892, and 6.2 more than it was in 1893. And yet during the year, as has been already shown, the new Division of Agricultural Soils has been established and the new Section of Agrostology erected in the Division of Botany.

It has been deemed desirable to reproduce here a full statement of the expenses of this Department for a period of fifteen years, from 1878 to 1892, inclusive, showing the objects of the several appropriations and the amount appropriated to each branch of the work. This statement presents in a condensed and practical manner a full history of the development of the Department.*

* For convenience these tables are omitted from this report and will be published in the form of a circular.

DIVISION OF RECORDS AND EDITING.

The Division of Records and Editing has issued during the past fiscal year two hundred and five (205) different publications. Fifty-six (56) of these were printed at the Weather Bureau. The remainder were published at the office of the Public Printer. All editions of the above publications aggregate 3,169,310 copies. They contained 10,512 pages. Farmers' bulletins were increased in numbers so as to make it possible to economically reach many readers. The reduction in the cost of printing for this Department during the year as compared with the previous twelve months is nearly $20,000. It is suggested, nevertheless, that an increase in the printing fund is necessary if all the information acquired by the Department through its several divisions is to be promptly printed, published, and disseminated.

In harmony with the Report of the Secretary of Agriculture for 1893, it is urged that the vicious system of promiscuous free distribution of departmental documents should be abandoned. Public libraries, educational institutions, and the offices of States and of the Federal Government might be furnished without cost, but from all individuals applying for the publications of the Department a price covering the cost of the document asked for should be required. Thus the publications and documents would be secured by those who really desire them for proper purposes. Half a million of copies of the Report of the Secretary of Agriculture are printed for distribution, at an annual cost of about $300,000. Many of these reports apportioned to members of the Senate and House of Representatives remain undistributed. Large numbers of the annual reports of this Department have been found cumbering the storerooms at the Capitol and the shelves of second-hand bookstores throughout the country. All this labor and waste could be avoided if payment of cost price were demanded for all Government publications.

As long as the custom or law requires the annual issuance of half a million of copies of this report, it is obviously the duty of those who make up that document to strive to render it instructive, interesting, and useful to all the people. It ought to contain the results of the researches made in the various bureaus and laboratories during the year, and should be so plainly written and popular in its character as to adapt itself to the practical farmer and be held in esteem by him as a work of reference on agricultural science, practice, and statistics. Such a handbook by the Department of Agriculture, with all purely executive matter eliminated, might prove of infinite service in the advancement and exaltation of the vocation of agriculture throughout the United States.

The chairman of the House Committee on Printing favorably reported a resolution at the last session of Congress providing for the printing of the report of this Department in two parts. As it passed the House

the resolution and the report of the committee, containing a letter from the Secretary of Agriculture with reference thereto, are appended.

[H. Res. 198, to print Agricultural Report for 1894.]

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Annual Report of the Secretary of Agriculture for the year eighteen hundred and ninety-four be printed. Said report shall hereafter be submitted and printed in two parts, as follows: Part one, which shall contain purely business and executive matter which it is necessary for the Secretary to submit to the President and Congress; part two, which shall contain such reports from the different bureaus and divisions, and such papers prepared by their special agents, accompanied by suitable illustrations as shall, in the opinion of the Secretary, be specially suited to interest and instruct the farmers of the country, and to include a general report of the operations of the Department for their information. There shall be printed of part one, one thousand copies for the Senate, two thousand copies for the House, and three thousand copies for the Department of Agriculture; and of part two, one hundred and ten thousand copies for the use of the Senate, three hundred and sixty thousand copies for the use of the House of Representatives, and thirty thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture: *Provided,* That the title of each of the said parts shall be such as to show that such part is complete in itself.

Passed the House of Representatives June 29, 1894.

[Report to accompany H. Res. 198.]

The Committee on Printing have considered House joint resolution No. 198, to print Agricultural Report for 1894, and report same with recommendation that it do pass.

The committee are of the opinion that it is wise to print said report in two parts, as provided in the resolution, with contents divided as suggested. This proposed change has been submitted to the Department of Agriculture, and has the approval of the Secretary, as shown by the letter from him herewith submitted.

DEPARTMENT OF AGRICULTURE, OFFICE OF THE SECRETARY,
Washington, D. C., June 21, 1894.

SIR: I believe that the Annual Report of the Department of Agriculture, distributed to the farmers of the country in such large numbers, could be greatly improved by publishing it in two separate parts, as follows:

Part 1 to contain purely business and executive matter, which it is necessary for the Secretary to submit to the President and Congress.

Part 2 to include such carefully prepared and selected matter, with proper illustrations, as will especially interest and benefit the farmers of the country, excluding everything that belongs to Part 1 and including a general report on the work of the Department, written with special reference to the needs of the farming public.

The advantages of such a division of the report are so apparent that no argument is needed to support them. The plan will give this Department the opportunity to prepare a report which will interest and benefit the farming classes more than anything which has hitherto been issued from it.

If this division is to be made it will be necessary that this Department be notified so that it can give early instructions to the chiefs of bureaus and divisions, who will soon begin the preparation of the annual report to be submitted on the 1st of December. I would respectfully suggest, therefore, the incorporation of some provision like that inclosed in the printing bill now under consideration by your committee.

Respectfully, yours,

J. STERLING MORTON,
Secretary.

Hon. JAMES D. RICHARDSON,
Chairman Committee on Printing, House of Representatives,
Washington, D. C.

In view of the possibly favorable action of the Senate on the foregoing resolution, the several chiefs of the various bureaus and divisions of the Department of Agriculture have been directed to prepare their reports in accordance therewith. It is believed that the result will supply a more useful, practical, instructive, and popular report than the late method has heretofore furnished to the public.

DEPARTMENT PRINTING OFFICE.

The constantly increasing demands for the printing of various blanks, letter heads, envelopes, circulars, etc., for use in the different divisions and bureaus has been promptly and satisfactorily met by the printing office under the control of this Department. Much of the work is needed for immediate use, and the ability to furnish it without delay demonstrates the efficiency of the present management. This office also prints the packets used in the distribution of seeds, of which, in September, October, and November, 4,747,550 were delivered to the Seed Division. During the year 1892–93, and for many years previous, the force consisted of 17 employees, working the entire year. In November, 1893, the force was reduced to 7 employees for twelve months and 8 temporary employees for seven months. During the first six months of the present year the number of impressions amounted to 8,210,110, against 5,201,665 during the same period of the preceding year; so that, with half the force, a third more work is now done, and that, too, of an improved quality.

DOCUMENT AND FOLDING ROOM.

The manual labor in this division has been nearly doubled, owing to the largely increased number of publications which have been issued during the past year. Notwithstanding this, the work of the division has been accomplished with celerity and certainty, although the force of employees has been considerably less than during the preceding year.

A record has been kept, for the first time since the establishment of the division, during the entire year, which shows each and every publication mailed from the Department of Agriculture. Three times as many packages were transmitted by the Department through the mails during the year as were sent out during the previous twelve months.

During the year this division committed to the mails of the United States two million two hundred thousand (2,200,000) pieces of franked mail matter.

The correspondence of the Document and Folding Room naturally increased very largely during the year, but it has been handled most efficiently by the clerical force. The entire mailing list of the Department is being revised and compiled so as to eliminate duplications from the mailing list. Already, in this readjustment of that list, duplication and triplication of names have been frequently discovered.

One address, indeed, has been found receiving twelve copies of each publication.

During the year there were purchased two patent mailing machines, which will very materially facilitate the addressing of documents.

DIVISION OF GARDENS AND GROUNDS.

The gardens and grounds of the Department of Agriculture, containing forty (40) acres, demand the constant attention of the superintendent and his subordinates. Glass structures cover nearly an acre of this reservation, and necessarily require the closest daily care and labor.

Several of the glass structures are used for the propagation of plants, of which many are used to embellish the grounds; but the larger portion, mainly those of economic value, are distributed throughout the States and Territories. During the last year there were thus distributed 75,000 plants.

The expenditures upon gardens and grounds for the fiscal year are somewhat reduced. At the present rate the salaries are $3,000 less than those of the last fiscal year. It is impossible to make any exact estimates as to the possible miscellaneous expenditures, in the future, of this division. Exigencies may occur which can not be computed with any degree of exactness before their necessity arises. In any event the appropriation recommended is deemed sufficient for this division.

OFFICE OF ROAD INQUIRY.

October 3, 1893, in pursuance of the act of Congress appropriating ten thousand dollars ($10,000) "to enable the Secretary of Agriculture to make inquiries in regard to the systems of road management throughout the United States, to make investigations in regard to the best methods of roadmaking, to prepare publications on this subject suitable for distribution, and to enable him to assist the agricultural colleges and experiment stations in disseminating information on this subject," the Office of Road Inquiry was instituted and Gen. Roy Stone, of New York, appointed to take charge thereof.

During the nine months of the fiscal year the work was necessarily of a tentative character. Bulletins Nos. 1 to 9, inclusive, of the Office of Road Inquiry, were collected, compiled, and published. These bulletins have been in such demand that first editions have, in many instances, been exhausted and reprints required.

During the year General Stone, besides attending to the literary work of the office, has attended and addressed conventions and meetings relative to road improvement in various States. It is proposed to increase the work of the office the coming year, to extend the inquiry on the same lines, and to publish maps showing the mileage of improved roads constructed in the United States during the last three years. The cooperation of the agricultural colleges and experiment stations will be

sought, so as to advance and disseminate a knowledge of the economic advantages of good roads and of the best methods of constructing them.

DIVISION OF STATISTICS.

There is no phrase in the English language which, by implication, conveys the impression of so much vast and exact knowledge as the word *statistics*. Literally it means "a state of," "a condition," or "a standing." It depicts, to one accustomed to dwell upon tabulated facts and figures, the mental image of a curious collection of valuable data and figures, caged in mathematical tables, for the purpose of elucidating facts which may be used in the further investigation of special subjects.

Statistical investigations should always be made in accordance with the rule of the theory of mathematical probabilities that "numerical fractions express the value of the degree of presumption in favor of the correctness of a particular event, when the causes or conditions which influenced the result are partly known and partly indeterminate."

Under this theory statisticians arrange results in numerical tables. Facts existing in large numbers are thus compactly and clearly set forth. Statisticians, therefore, should not be content with giving deductions which admit of serious doubts. It is the duty of the statistician to supply credible materials whence anyone may, by examination and reasoning, evolve his own deductions.

But statistics do not consist entirely of columns of figures. Conclusions may be fairly drawn only from well-attested data, though in many instances they may not be susceptible of mathematical demonstration.

The particular object of this division of the United States Department of Agriculture is the ascertainment, by diligence and care, of the actual and real condition of the farms and farmers of this country. Its duty is to seek the causes which produced that condition. The utility of ascertaining the condition is in the service which the ascertained facts may render in improving or mitigating, intensifying or repressing, that condition.

A further important utility is found in agricultural statistics, through their elucidation of the relation of the supply of farm products to the demand for farm products in the markets of the United States, and in the other markets of the world. Before the statistician begins an investigation in any certain line he should be sure that the agriculture, commerce, and manufactures of this country need to know the facts which he proposes to gather. And in all researches statisticians should be ready to receive suggestions from those versed, either by experience or observation, in the subject which they consider, and they should be always without prejudice and ready to abandon with alacrity any hypotheses which they find untenable. The statistician's collection of materials should be willingly submitted, on demand, to any new tests which occasion may offer. And no statistician of an economic subject so vast as

that of the agriculture of the United States can approximate the truth with frequency and certainty, unless he has some knowledge of the calculus or computation of probabilities.

Enough has been stated to show that no person can become a successful statistician, an assistant statistician, the chief of a section in the Division of Statistics, or even a thoroughly competent clerk in that division, who is not well posted in the literature of European and American statistics. It is quite plain also that each person engaged in making up statistics for American use, from foreign tabulations, should be perfectly acquainted with the metric system of weights and measures. In that system all foreign statistics, except those of Great Britain, are computed.

COMPETITIVE EXAMINATIONS.

There is no line of investigation which requires more intellectual discipline, more accuracy of judgment, more patience in research, more skill in combining and correlating facts and figures, or more special training for its pursuit, than the line followed by the painstaking and successful statistician. Holding such opinions, the Secretary of Agriculture is convinced that every person employed in gathering statistics under the chief of that division should be admitted to that work only after a thorough, exhaustive, and successful examination at the hands of the United States Civil Service Commission. Therefore, he has called for such examinations, by that honorable body, of candidates for the positions of assistant statistician and for chiefs of sections in the Division of Statistics. When these examinations transpire, any employees now in that division of the Department of Agriculture are at liberty, with other competitors, to test their peculiar fitness and adaptation for that work by submitting to the examination.

It is quite certain that their long experience with the facts and figures that are received from day to day in that division will be no disadvantage to them in the contest with outsiders who have had no such contact.

STATE AND COUNTY AGENTS.

A fundamental objection to the present system of gathering agricultural statistics in the United States is the fact that correspondents, who are expected to furnish reliable data, are paid nothing for their work. The Government is endeavoring to get something for nothing. The only payments (for services) made to these thousands of correspondents in all the counties of each State and Territory are public documents, garden seeds, and a few postage stamps.

The service has been very much better than its compensation. In the several States and counties have been found very many zealous and enthusiastic men anxious to do this work. But they are the exception. Human nature, as a rule, is not desirous of doing diligent duty in any line without remuneration.

In addition to the county agents, the Federal Government has a State statistical agent in each State and Territory of the Union. The salaries for these agents range from $400 to $1,200 per annum each. As a rule they are competent and accomplished men, but the service would be vastly improved if all these appointees were placed in the classified service, so that hereafter, when a vacancy occurs, the person appointed to fill it shall have passed an examination before the United States Civil Service Commission, demonstrating his fitness and adaptability for the proper discharge of the duties pertaining to the position.

WORK OF THE YEAR.

The Division of Statistics is, for convenience of administration, divided into four sections, as follows: Compilation and foreign statistics; answers to Congressional inquiries and all verification of agricultural statistics are conducted in this section. Records, files, and correspondence; the title of this section clearly expresses the nature of the duties assigned to it. Crop reporting, which covers all investigations into crop conditions, and collecting and tabulating the reports of correspondents. Freights; the work of this section consists in crosschecking the compilation of crop reports, computations, and freights.

The total expenditures in behalf of the Division of Statistics, including salaries of employees, during the last year, were one hundred and ten thousand dollars ($110,000).

During 1894 the Division of Statistics has enlarged its work upon the crops of the United States. The data for the final report for 1893, containing estimates as to the area, product, and value of the principal crops, were secured by the issuance of 135,000 interrogative circulars addressed to farmers and others who were selected for their high character and intelligence.

Early in 1894 the usual investigation was made as to probable changes in the areas of the principal crops of the Republic, and the results of those inquiries were published in the report for May. The annual inquest as to the quantity of corn and wheat in farmers' hands on the first day of March was thoroughly made, and the facts found were published in the report for March. It contained also a comparison with the corresponding data for a number of previous years and a review of the production and distribution of the several cereals for a term of years. Since then a carefully prepared review of the "supply and distribution of wheat for twenty-five years" was given to the public. A tabulated statement showing the wholesale prices of a number of principal agricultural products at leading cities in all sections of the United States was also presented in the report of the Statistician for March, 1894.

Careful inquiry has been made as to the cost per bushel of producing wheat and corn. Replies from thirty thousand (30,000) farmers and four thousand (4,000) experts were received. Their findings were

published by States and by sections. The State findings were those of experts, and the findings as to particular sections were by leading farmers.

Two other inquiries made by the Division of Statistics were of great interest. The first related to the average weight of wool fleeces in the United States, and the second was relative to the health of the people in the several States and Territories, and was issued for the purpose of ascertaining the diseases most prevalent in each.

The annual table of the world's wheat crop published by this division consists in part of official figures, and in part of such unofficial estimates as are deemed worthy of confidence. This table has been gradually increasing in correctness and accuracy. Its composition is a work of great care and diligent research, involving examination of reports in many languages.

In addition to these customary reports and publications, much time was spent in the preparation of special reports on a variety of subjects of interest to farmers and business men, which, as usual, found a place from time to time in the monthly reports.

AN ANNUAL AGRICULTURAL CENSUS.

Is it not probable that satisfactory statistics of the agriculture of the United States could be better obtained through State authorities? Each Commonwealth, in its labor bureau, or in some other of the executive branches of its government, could establish a properly paid bureau of statistics, and through county agents gather reliable data quickly. The statistics thus collected would be sent by the commissioners in charge of statistics at the several State capitals directly to the Agricultural Department. In that manner possibly a more thorough, reliable, and credible collection of agricultural statistics might be made. If the tables are worth making at all, they are worth making correctly and credibly. If, however, the present system is to be continued, advantages would result from an annual census of agricultural acreages and crops. It is needed as a basis for even approximate accuracy in estimating crop conditions. To give the average condition of any crop in any State certain average weights are applied to each county estimate. Such weights should of course be based on the acreage of each crop in each county. As a fact, they are obtained apparently from acreages reported by preceding United States census, regardless of the increase or decrease from year to year in each county of the area devoted to the several crops. This fundamental fallacy seems to have permeated the agricultural statistics for many years, and it is clear that there must be only guarded and limited faith in the possible accuracy of the crop estimates of the Division of Statistics up to a very recent period of time. Effectual elimination of all possibility of such erroneous calculations is only feasible by means of such an annual census of acreages, which might be taken by some of the experienced men who now report

to the Department, provided they are paid for the work. The precise information desirable by the taking of this census is as follows:

(1) The area under each of the more important crops.

(2) The aggregate product of each of such crops.

(3) The quantity of wheat and corn in the hands of farmers at a date after the spring sowings and plantings and before the beginning of harvest; and also the quantity of cotton and tobacco remaining in the hands of planters, either at the same date or at some other designated time.

(4) The number of farm animals on the 1st of January of each year.

Such a census, to be carefully made by practical men, experienced in agriculture, who may be selected out of the large number of competent persons who have been doing gratuitous work in this line for many years, is very much favored by Mr. Henry A. Robinson, the efficient chief of the Division of Statistics. He estimates that the actual cost of collecting for the census certain agricultural statistics, which may be considered about equivalent as regards the labor of collection to those just proposed, would be not far from five hundred thousand dollars ($500,000), and desires that an appropriation of that sum for the work of collecting such statistics during the fiscal year ending June 30, 1896, be made.

In Great Britain the agricultural statistics are as nearly correct as possible, because each farm is accounted for as to the amount of acreage in each crop and as to the number of domestic animals of each species. Furthermore, the yield of each sown or planted crop per acre is given, together with the number of poultry, eggs, and pounds of butter produced—all of which is signed by either the tenant farmer or the proprietor. This exactness is reached through the revenue systems of foreign countries. It might possibly be approximated in the various counties and States of the American Union through similar agencies, or by United States revenue collectors and their deputies.

THE GRATUITOUS PROMISCUOUS DISTRIBUTION OF SEED.

The Secretary of Agriculture calls attention to the report of this Department for the year 1893, and particularly to page 17 thereof, under the head of "Distribution of seed at the public expense."

Briefly, he recommends that the purchase of seeds for gratuitous and promiscuous distribution be utterly abolished, and that not one cent be appropriated for such distribution.

During the fiscal year ending June 30, 1894, the Seed Division gave out to Senators, Representatives, and Delegates in Congress seven million four hundred and forty thousand nine hundred and eighteen (7,440,918) papers of vegetable seeds, six hundred and forty thousand and sixty-five (640,065) papers of flower seeds, sixty-three thousand seven hundred and forty-six (63,746) papers of tobacco seed, one hundred and eighty-two thousand five hundred and forty-two (182,542) papers of turnip seed, thirty-five (35) quarts of mangel-wurzel seed,

five hundred and twenty-one (521) quarts of sugar-beet seed, four thousand eight hundred and seventy-three (4,873) quarts of rape seed, fifty (50) quarts of oats, twenty-five (25) quarts of sorghum, eleven thousand seven hundred and six (11,706) quarts of corn, ten thousand one hundred and sixty-six (10,166) quarts of grass seed, nine thousand two hundred and ninety-three (9,293) quarts of clover seed, and twenty-one thousand one hundred and sixty-six (21,166) quarts of cotton seed.

In that distribution there were one hundred and seventy-seven (177) varieties of vegetable seed, sixty-five (65) of flower seed, seven (7) of tobacco, one (1) of wheat, five (5) of corn, three (3) of oats, one (1) of barley, five (5) of grass, four (4) of clover, six (6) of sorghum, one (1) of Kaffir corn, one (1) of Jerusalem corn, two (2) of millo maize, two (2) of soja beans, one (1) of cowpeas, one (1) of flat peas, one (1) of serradella, one (1) of spurry, one (1) of hairy vetch, one (1) of rape, eight (8) of turnips, three (3) of sugar beets, one (1) of mangel-wurzel, one (1) of peanuts, and ten (10) varieties of cotton.

In the distribution, Senators, Representatives, and Delegates in Congress sent out eight million three hundred and eighty-five thousand one hundred and twenty (8,385,120) packages; county statistical correspondents of the Agricultural Department, five hundred and seven thousand six hundred and sixty-one (507,661); State statistical agents of the Department, one hundred and forty-one thousand one hundred and twenty-nine (141,129); experiment stations and experimental farms, fifty-two thousand two hundred and twenty-eight (52,228); agricultural associations and miscellaneous applicants, four hundred and sixty-nine thousand one hundred and eighty (469,180). So that the aggregate number of packages of seed gratuitously distributed by the Government of the United States in the fiscal year is nine million five hundred and fifty-five thousand three hundred and eighteen (9,555,318).

The cost of this enormous distribution, not including the carriage of the packages (which amount in weight to more than three hundred tons), as dead matter by the postal service, is as follows:

For the purchase and distribution of seeds	$111,242.51
Payment of statutory salaries in Seed Division	12,400.00
Making a total of	123,642.51

That total is divided as follows:

Paid out for seed	$56,968.66
Paid out for freight and express charges	2,858.97
Paid out for grain bags	182.08
Paid out for salary and expenses of special agent	3,010.59
Cost of seed delivered at Department	63,020.30

After the reception of the seed the Department paid—

For labor in the seed room (laborers' roll)	$34,690.75
Skilled labor	5,643.99
Paper bags, twine, tags, and other supplies	7,887.47
Statutory salaries	12,400.00
Cost of preparing seed for distribution	60,622.21

The above statement shows that $60,622.21 was spent in preparing seeds for distribution—a sum in the aggregate lacking less than $3,000 of the cost of the seed delivered.

The cost per package of seed distributed is 1.29 cents, against 2 cents for the preceding year.

During the fiscal year 1892–93 the number of seed packages distributed was seven million seven hundred and four thousand four hundred and sixty-four (7,704,464); and during the year 1893–94 the number of packages distributed is nine million five hundred and fifty-five thousand three hundred and eighteen (9,555,318). The total expenditure for the fiscal year 1892–93, including the statutory salaries and compensation of others detailed to this work, was one hundred and sixty thousand dollars ($160,000), and for the year 1893–94 one hundred and twenty-seven thousand seven hundred and eight dollars ($127,708).

The extravagance and inutility of these disbursements are apparent to any person who will investigate the results of the expenditure. That the distribution is regarded with very little interest is evidenced by the fact that, taking nine millions of papers of seed, there is an average of five papers to each person, for it is safe to say that there were 1,800,000 citizens of the United States who received seeds out of this promiscuous distribution. Out of this number nine hundred and forty (940) persons acknowledged their receipt, and in those cases it was generally with a request for more seed. The State of Iowa sent 35 acknowledgments, Kansas 30, Connecticut 16, New Jersey 2, Nebraska 33, New York 62, New Hampshire 5, Rhode Island 1. The other States indicate about the same degree of indifference, so that there are less than one thousand acknowledgments by more than one and three-quarter million recipients.

In view of the above, it is difficult to see how any practical statesman can advocate an annual disbursement of $160,000 for such a purpose. Educationally, that sum of money might be made of infinite advantage to the farmers of the United States if it were expended in the publication and distribution of bulletins showing, in terse and plain language, how chemistry, botany, entomology, forestry, vegetable pathology, veterinary, and other sciences may be applied to agriculture.

If, in a sort of paternal way, it is the duty of this Government to distribute anything gratuitously, are not new ideas of more permanent value than old seeds? Is it a function of government to make gratuitous distribution of any material thing?

No estimate has been made for an appropriation for the purchase of seeds for the next fiscal year. If it is deemed best to make such an appropriation, it is recommended that $500 be allotted to each one of the experiment stations of the several States and Territories, which for forty-eight (48) stations would amount to $24,000. Such a law should provide that each station purchase such new and improved varieties of seeds, cuttings, and bulbs as, after examination, may seem

to its director probably adaptable to the soil and climate of the State in which his station is located. If there ever was any sound statesmanship in this gratuitous distribution of seed, which has already cost the Government of the United States several millions of dollars, the reason and necessity for such distribution was removed when the experiment stations were established in the several States and Territories. Those stations are in charge of scientific men. They are, therefore, particularly well equipped for the trial, testing, and approval or condemnation of such new varieties as may be introduced from time to time.

LIBRARY.

Since the present librarian, Mr. W. P. Cutter, who was certified by the United States Civil Service Commission, took charge of the library of the Department of Agriculture, modern methods have been introduced, for the first time, into its conduct. A dictionary catalogue has been instituted, and the books have been arranged in a regular system, in accordance with which the valuable material in it will be made available for students. The increased appropriation has been used to fill out the fragmentary sets of scientific periodicals and to purchase works bearing upon the sciences studied by the Department experts. A reading room has been arranged and increased facilities provided for the convenience of investigators. The library has been made in this manner a working laboratory instead of a miscellaneous storehouse.

OFFICE OF FIBER INVESTIGATION.

A report on the uncultivated bast fibers, such as are found upon the inner bark of plants, was completed during the year by the Office of Fiber Investigations, and also a paper on the method of tillage and manufacture of ramie, which contains careful estimates of the cost of instituting ramie plantations, with reliable figures as to the probable or possible yield. The inquiry as to the production of flax in the region of Puget Sound, Washington, has been continued. Flax grown in that region during the past season has been retted and prepared. Though the local agents engaged in this work did not—because of lack of experience—perfectly perform their duties, nevertheless, practical flax planters, who examined their product, have declared that Washington flax would produce, with skillful treatment, a very fine quality of fiber.

DIVISION OF MICROSCOPY.

Studies have been continued in this division upon the edible and poisonous mushrooms. These investigations have aimed to discriminate between edible and nonedible varieties and to give the people of the country plain and safe directions by which they might know them. It is hoped that in this way our neglected resources among these fungi

may become better known and more used. For the purpose of giving assistance to amateurs in mushroom culture experiments have been made to ascertain the better method of cultivating mushroom spawn.

Investigations on butter and butter fats have also been continued. Requests are constantly received from official chemists, chemists of State boards of health, etc., for information or assistance with regard to the identification of oleomargarine, butterine, and the various lard substitutes, and for discriminating between the different lubricating oils, etc.

Nearly two thousand careful measurements of the length of fibers of the cotton staple, domestic and foreign, and the average, together with the maximum and minimum lengths, has been recorded.

OFFICE OF IRRIGATION INQUIRY.

The chief of the Office of Irrigation Inquiry passed the earlier months of the year in Nevada, California, Arizona, New Mexico, and Utah collecting information as to the modes of irrigation most successfully used in those States and Territories. In that tour relations were established between this office and the people directly interested in this system of cultivation, from which it is hoped good may come in the way of additional practical information. It is believed that all those engaged in farming in the arid and subarid regions where irrigation is practiced may soon be brought into immediate correspondence with the Department.

The office has given some attention to the study of percolation and evaporation in the Rocky Mountain regions, where the annual snowfall is the source of many of the streams which fertilize the plains below.

BUILDINGS.

Neither the character nor the condition of the buildings of the Department can be truthfully commended. There are many wooden structures in the rear of the main edifice which are a constant menace because of the combustible materials of which they are constructed. The laboratories in and about these buildings are constantly using alcohol, gas, oils, ether, and other inflammable and explosive substances. It is therefore imperatively necessary that such laboratories, together with all divisions which by their experiments may possibly create conflagrations, should be removed from these Government buildings.

In view of the tinder-box character of the subsidiary buildings of the Department, it is recommended that all the laboratories and shops be removed to rented brick buildings across the street, in the rear of the Department grounds, provided said buildings can be secured by a reasonable annual outlay of the public money.

The act creating this Department declares as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby established at the seat of Government a United States Department of Agriculture, the general designs and duties of which

shall be to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word, and to procure, propagate, and distribute among the people new and valuable seeds and plants.

But there was no building provided for the Department of Agriculture under that act, and rooms were assigned to the Commissioner and his employees in the basement of the Patent Office, where they remained six years. In 1867 one hundred thousand dollars ($100,000) was appropriated for the present main building of the Department, and it was occupied in 1868. From that time, with a few minor changes in the interior, this building has remained practically unchanged. It is 170 feet long by 61 feet in breadth. It has a basement, three full stories, and an attic. This building contains, exclusive of halls, 6,860 square feet of available floor space in the basement; 5,800 square feet on the first floor; on the second floor, including the galleries in the library, there are 10,344 square feet; on the third floor, 2,384 square feet; and there are 4,558 square feet in actual use in the attic, aggregating in occupancy at present 29,946 square feet of floor space. The basement, two thirds of which is below the surface of the ground, contains the boiler and fuel rooms, the storerooms of the Property Division, the laboratory of the Division of Ornithology and Mammalogy, the post-office, and the printing office; and in this ill-lighted and badly ventilated place from 25 to 30 people, including the engineers and firemen, are almost always at work.

The library requires the larger portion of the second and third floors of the building. Little space, relatively, is used for the offices of the Secretary, Assistant Secretary, and chiefs of division. The attic of the main building contains the offices and laboratories of two of the most important divisions. Excessive heat and defective ventilation are unavoidable in these apartments.

The building just described was erected to accommodate the Bureau of that date, composed of four divisions and employing fifty (50) persons. Those divisions, with the laboratory and Museum, fully occupied the building at the time of its completion. Pressure for space becoming greater from year to year, and adequate appropriations for the erection of substantial buildings having failed, the Department has been forced to erect cheap wooden structures upon the grounds. In such buildings is sheltered much valuable property. The Museum building cost about ten thousand dollars ($10,000). A better building to burn could not be invented or constructed, and yet it contains a Museum which, on the market, is worth at least one hundred thousand dollars ($100,000). Annually the Government is paying more than seven hundred thousand dollars ($700,000) for agricultural experiment stations in the several States and Territories. The cost of a central office in this Department for collating, compiling, and publishing the reports of these stations is each year twenty-five thousand dollars ($25,000). The chief records of the Office of Experiment Stations are compiled and stored in

this combustible wooden Museum building. In it are stored the records of the results of agricultural experiments for which the United States Government has already paid out nearly five millions of dollars ($5,000,000). The same building contains the publications of the Department and the offices of several important divisions, together with all the valuable data which each has acquired.

In wooden buildings of equally combustible character are housed the testing laboratory of the Division of Forestry; the carpenter shop; stores of seeds; soil samples, collected at no inconsiderable expense from all parts of the Republic; and all tools and implements used by the superintendent of gardens and grounds and the various scientific bureaus.

As the work of the scientific divisions multiplied it became necessary some years ago to rent two private buildings on B street SW. One of them is occupied by the laboratory of the Bureau of Animal Industry, and the other is the domicile of the Chemical Laboratory of the Department. For the first-mentioned building is paid $1,200 per annum rent, notwithstanding the Government preliminarily expended about $6,000 in adapting the various rooms for present purposes and fitting them with gas, laboratory desks, steam, and water. The Chemical Laboratory building costs $75 per month rent, although the Government had expended $4,500 thereupon in making similar improvements. There is hardly a university or agricultural college in the United States which has not better constructed, better lighted, and better ventilated laboratories than those used by the Department of Agriculture.

Since its removal from the Patent Office, twenty-six years ago, and its establishment as a Department, only one hundred and fifty-four thousand dollars ($154,000) have been appropriated for buildings for its use, exclusive of the Signal Office building purchased while that office was in the War Department. During the same number of years other Departments of the Government have expended for the erection of buildings in the city of Washington, up to June 30, 1894, inclusive, $19,126,826.09.

In view of the fact that the Department of Agriculture is maintained to educationally supervise that industry which furnishes the solid, fecund source of the revenues whence all that vast sum of money was derived, it may not be inappropriate to suggest more commodious accommodations for its further development and usefulness.

The Weather Bureau, at the corner of Twenty-fourth and M streets, is too remote from the Department to receive that personal daily supervision of the Secretary which its magnitude and importance require. It is evident that this valuable property which the Government now owns, and upon which the Weather Bureau building stands, could, if authorized by law, be sold very advantageously. It is believed that it would probably bring a sum of money sufficient to erect substantial buildings for the Department of Agriculture, wherein the Weather

Bureau and all the other divisions and laboratories might be suitably provided for.

With the more than seven hundred thousand dollars ($700,000) saved since March 7, 1893, from the regular appropriations to this Department and covered back into the Treasury of the United States, and the amount the Weather Bureau property would certainly bring, it does seem that buildings commensurate with the relative value which agriculture bears to other vocations and pursuits might be erected at an early day.

FARM PRODUCTS AND THE MONEY THEY BRING.

It will no doubt prove a matter of infinite pride and satisfaction to the real farmers—the practical agriculturists—of the United States to learn that, out of the total exports of this country for the fiscal year 1894, including the products of the mine, of the forest, of the fisheries, of the manufactories, together with every miscellaneous commodity—amounting to eight hundred and sixty-nine million two hundred and four thousand nine hundred and thirty-seven dollars ($869,204,937)—farm products aggregate a value of six hundred and twenty-eight million three hundred and sixty-three thousand and thirty-eight dollars ($628,363,038). All the other exports in that year from this Republic amount to only two hundred and forty million eight hundred and forty-one thousand eight hundred and ninety-nine dollars ($240,841,899). This proves that for the fiscal year 1894 the exports evolved by farmers from the farms of the United States were 72.28 per cent, in cash value, of the total exports of the American Republic for that period of time. This is demonstrated by the following table:

	Amount.	Per cent.
Agriculture	$628, 363, 038	72. 28
Mining	20, 449, 598	2. 35
Forest products	28, 010, 953	3. 22
Fisheries	4, 261, 920	. 49
Manufactures	183, 718, 484	21. 14
Miscellaneous commodities	4, 400, 944	. 52
	869, 204, 937	100

European markets and all the other markets of the world are demanding from the American farmer the very best quality of breadstuffs and meats. They demand them inspected and governmentally certificated to be of the highest sanitary, nutritive, and edible quality. But farm products have only a specific purchasing power. They will only buy money of people who desire farm products. The farmer exchanges these results of his labors, which have a specific purchasing power, for money, which has a general purchasing power. It is important, therefore, to farmers everywhere that they demand money for their products which has the highest general purchasing power throughout all the

civilized world. It is as vital to the American agriculturist that the currency of his country should be on the basis of the highest and most universally recognized measure of value as it is to the reputation of American farm products in all the world's markets that they be of the most desirable quality.

FOR PRIME PORK GIVE US PRIME CURRENCY.

Would the six hundred million dollars' worth of farm products from the United States sold last year to foreign nations have been as remunerative to the American farmer if they had been paid for in silver as they have been when paid for in gold or its equivalent?

When the standard coin of the Republic shall be made of metal worth as much after it is melted as it purports to be worth in coin, and the mint value and the bullion value of all coined money is nearly the same, will not the American farmer and all other citizens become more permanently prosperous?

If the American farmer, laborer, and manufacturer are compelled by law to submit to the measurement of the value of the products of their efforts by a silver standard, will not the foreigner in buying those products always use the same measure? With his beef, pork, and cereals the American farmer *buys* money, and why should he not demand as superlative quality in that which *he buys* as the domestic and foreign purchasers insist upon in that which *he sells?* If those buyers demand "prime" beef and "prime" pork, why should not the farmer demand "prime" currency, the best measure of value, the most fair and facile mediation of exchanges, in the most unfluctuating money which the world of commerce has ever evolved?

In closing his report for the fiscal year 1893 the Secretary of Agriculture said:

> A year from this time, it is hoped, after consultation with the Congressional committees and other representative forces which are endeavoring to educationally develop and define duties for this Department, that useful progress in the right paths may be truthfully reported.

Therefore the foregoing statements as to the practical workings of the Department are this day submitted as a partial fruition of the hope then earnestly and sincerely expressed.

J. STERLING MORTON,
Secretary.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., November 20, 1894.

THE FEDERAL MEAT INSPECTION.

By D. E. SALMON, D. V. M.,
Chief of the Bureau of Animal Industry, U. S. Department of Agriculture.

GROWTH OF THE INSPECTION.

The inspection of meat by the Federal Government was begun in May, 1891, under the jurisdiction of the Bureau of Animal Industry, and in accordance with an act of Congress approved March 3, 1891. Considerable time was required to organize the force and systematize the work, and consequently the quantity of meat inspected in the fiscal year ending June 30, 1891, was not very large.

The law requires that the inspected meat be marked for identification, and this is accomplished by attaching a meat-inspection tag to each quarter or piece with a wire and lead seal. These tags enable the consumer to learn whether the meat which he is buying has been inspected, because if the wires are properly sealed the tags can not be removed from one piece and attached to another. The tags are also intended under the law as a means of identifying meat which may be shipped from one State into another State or to any foreign country.

When the law is fully complied with, only inspected meat can be used in interstate or foreign commerce. All meat shipped abroad is now inspected, and has been since the beginning of the fiscal year 1892; but the large number of abattoirs which do an interstate trade has made it impossible up to the present time to extend the service sufficiently to include them all. As the inspectors and assistant inspectors were, however, recently placed in the classified service, it is probable that a larger number of reliable and competent men can be secured than under the old system, and that the inspection service can be correspondingly extended.

In the fiscal year ending June 30, 1891, the inspection being enforced during the months of May and June only, there were inspected and tagged 66,804 quarters of beef for export and 165,378 for the interstate trade. There were also inspected and stamped 1,594 packages of canned meat, 25 of salted meat, and 28 of smoked meat, and the carcasses of 2,216 hogs were inspected microscopically.

These figures show that there was only a beginning of the inspection made in the fiscal year 1891, and that to obtain data from which conclusions of any kind can be drawn we must begin with the fiscal year 1892. The system and methods of inspection then in force were practically the same as are now used, but more or less important modifica-

tions of the details have been made from time to time as experience indicated was desirable.

In 1892 there were inspected 1,190,771 quarters of beef for export and 8,160,625 for the interstate trade. In addition there were inspected 583,361 carcasses of sheep and 59,089 carcasses of calves. The number of hog carcasses microscopically examined reached 1,267,329.

A part of the meat inspected is shipped in the carcass and is identified by the meat-inspection tags; but very much of the meat is canned or salted, and this is identified by meat-inspection stamps placed upon the crates or boxes in which the cured meat or cans are packed. Very often cured meats are shipped in bulk, the pieces being placed directly into the cars without covering of any kind. In this case the car forms the package and is sealed with the same seal that is used for attaching tags to pieces of meat.

There is need of a cheap and easily applied method for marking pieces of meat which are too small to be tagged. Tags are effectual in marking quarters and carcasses of meat, but are too expensive to be applied to the smaller pieces. Aniline inks are used in some countries, but the samples so far examined by the Bureau of Animal Industry have not proved satisfactory. These inks are affected by moisture and are liable to become smeared over the meat, damaging its appearance and obliterating the identifying mark.

The number of packages of meat stamped in 1892 was as follows: Canned meat, 495,577; salted meat, 142,698; smoked meat, 159,432.

During the fiscal year 1893 there were inspected and tagged 1,036,809 quarters of beef for export and 10,534,102 quarters for the interstate trade. There were also inspected 92,947 carcasses of calves and 870,512 of sheep. The number of hog carcasses microscopically examined reached 1,960,069.

The number of packages of canned, salted, and smoked meats and other meat products stamped during the year reached 1,035,569.

Previous to the fiscal year 1894 no inspection had been attempted of hogs at the time of slaughter. The carcasses of those for the export trade to continental Europe had been microscopically examined for trichinæ, but this inspection is, of course, insufficient to reveal any other disease with which the animals might be affected. This year the same method of inspection before and after slaughter has been applied to hogs as has been in operation with cattle during the whole period of inspection.

During the fiscal year ending June 30, 1894, there were inspected and tagged 2,417,312 quarters and 4,022 smaller pieces of beef for export; and 10,810,202 quarters and 748 packages of fresh beef for interstate trade. The number of packages of canned meat stamped was 636,227, and of salted and smoked meat, 487,011. The number of hog carcasses microscopically examined was 1,194,663, and of pieces of pork, 177,747; a total of 1,372,410 carcasses and pieces.

The number of animals inspected at the time of slaughter is shown in the following table:

	1891.	1892.	1893.	1894.
Beef cattle	83, 891	3, 167, 009	3, 922, 174	3, 862, 111
Calves		59, 089	92, 947	96, 331
Sheep		583, 361	870, 512	1, 020, 764
Hogs				7, 964, 850
Total	83, 891	3, 809, 459	4, 885, 633	12, 944, 056

The meat inspection is now in operation at 46 abattoirs, situated in 17 cities.

The exports of microscopically inspected pork by fiscal years have been as follows:

	1892.	1893.	1894.
	Pounds.	*Pounds.*	*Pounds.*
To countries requiring inspection	22, 025, 698	8, 059, 758	18, 845, 119
To countries not requiring inspection	16, 127, 176	12, 617, 652	16, 592, 818
Total	38, 152, 874	20, 677, 410	35, 437, 937

A large quantity of the pork which the records show to have been exported to countries not requiring inspection was shipped to Belgium and Holland, and even to England, for reshipment to Germany and France. This was on account of the packing houses having agents in those countries, to whom large consignments were made, and these agents sold the meats in smaller quantities and forwarded them to their destination. The cases of provisions were all marked with the inspection stamp of this Bureau, and were covered by certificates, so that they were undoubtedly sold as American inspected pork.

The small proportion of inspected pork which was shipped directly to countries requiring inspection in 1893 is explained by the high prices here and the decreased demand in those countries.

DISEASES DISCOVERED BY THE INSPECTION.

The number of cattle found diseased, the carcasses of which were condemned as unfit for human food, was 4,127; the number of sheep carcasses condemned was 466, and the number of carcasses and pieces of pork found to contain trichinæ was 33,013. In the ante-mortem inspection of hogs 8,624 were rejected, and in the post-mortem inspection 17,435 carcasses and 12,940 parts of carcasses were condemned.

While the number of diseased animals discovered at the abattoirs shows the necessity of the inspection, it must be admitted to be exceedingly small compared with the immense number of animals examined. The meat-producing animals, and particularly the bovine animals, of the United States are in better health and better condition as a whole

when they go to market than are the animals of most other countries. Among the 3,862,111 cattle inspected, but 765, or about 1 in 5,000, were found to have tuberculosis sufficiently advanced to justify condemnation. Actinomycosis was found in 321 cases, Texas fever in 28, while 707 animals were condemned on account of advanced pregnancy, and 1,931 for bruises received during transportation.

Among the diseases reported, the most dangerous to the consumer are those in which septic processes are in progress or likely to be developed. As affected with this group of diseases cattle were condemned as follows: Septicæmia, 100; pyæmia, 16; gangrene, 73; peritonitis, 18; enteritis, 30; metritis, 3; abscess, 53; or a total of 293.

The proportion of carcasses and pieces of pork found to contain trichinæ was smaller than in the preceding year, being 2.4 per cent as compared with 3 per cent in 1893.

REASONS FOR CONDEMNING CARCASSES.

Although upon superficial consideration the meat inspector's task may seem simple and his duty plain, there are in practice many troublesome problems to solve. Should carcasses be condemned for all diseases, or only for those which are likely to injuriously affect the health of the consumer? Should pregnant females and those which have recently given birth to young be condemned; and if so, at what point shall the line be drawn separating those which are fit for food from those which are not? These are the most perplexing questions and the ones upon which scientific men are most divided.

In most European countries the inspection of meat is considered as a strictly sanitary question, and a disease which is not likely to injure the health of the consumer is not accepted as sufficient reason for condemning the carcass. Acting upon this principle, carcasses of animals affected with pleuro-pneumonia, foot-and-mouth disease, actinomycosis, pneumonia, Texas fever, and similar diseases would be considered fit for food if the carcasses show no signs of emaciation. The meat from animals in an advanced period of gestation or those which have recently given birth to young would also be passed as edible. Tuberculous carcasses which would be dangerous are in some countries sterilized by heat and then sold for human food.

There can be no doubt that the people of the United States are more particular in regard to the quality and character of the food they eat than are those of any other country. There is an almost universal sentiment against eating the meat of animals affected with any disease, whether it is communicable or injurious to the consumer or not. There is a repugnance to the meat of female animals when parturition is approaching or has recently occurred, while the flesh of very young animals or of those which were unborn at the time the mother was slaughtered is regarded as even more offensive.

In the Federal meat inspection it has been considered a duty to pro-

tect the consumer from meat which was offensive and repugnant to him, as well as from that which was actually dangerous to his health.

This principle has been criticised by some and considered untenable by others; but as a matter of fact it has been admitted and acted upon in all countries where meat inspection is anything better than a farce. For instance, the meat of emaciated and anæmic animals is generally condemned, not because their flesh produces any disease in the consumer, but because it is innutritious and offensive. No meat inspector would think that he could properly allow the carcasses of dogs, cats, or rats to be passed and sold for human consumption. Nevertheless, we have no reason to suppose that the meat of these animals would produce disease in the person who ate it. A meat-inspection service, however, which does not protect the consumers from meat so offensive to them, and which they would under no circumstances purchase if they knew its character, would not be worthy of support.

Acting upon this principle, the inspectors of this Bureau have been instructed to condemn the carcasses of all animals having acute diseases or high fevers, as well as the specific diseases liable to be communicated to or to cause disease in the consumer. Females are also condemned because of approaching parturition or because they have recently dropped their young.

Though abattoirs where slaughtering is conducted exclusively for the local market are not embraced by this inspection, the consumer may protect himself against those dealers who would fraudulently sell the meat of such animals as have just been mentioned by assuring himself that the carcass bears the meat-inspection tag of this Bureau, attached with an unbroken seal.

A more complete protection is realized by means of a recent order requiring the inspectors to seize upon all animals and carcasses unfit for food and dispose of them in such way as to render impossible the selling of the meat as an edible product.

ADVANTAGES AND DISADVANTAGES OF LARGE ABATTOIRS.

Sanitary authorities favor a few large central abattoirs rather than many small ones, because the slaughtering business is then concentrated, and the supervision may be conducted at less expense and in a more thorough manner. For this reason the small slaughterhouses which exist in nearly all cities, and which as a rule have little or no inspection, should be closed, and all slaughtering should be done at a central abattoir where inspectors are constantly present.

The small establishments are often in a filthy condition, and they are frequently operated by irresponsible and unprincipled parties who would not hesitate to endanger the health of a whole community if by so doing they could increase their profits by a few dollars. It is at these small abattoirs, where animals are slaughtered almost entirely for local consumption, that the greater part of the unsound and diseased

meat which reaches the market is prepared for human food. The abominations of some of these places are unspeakable, and the wonder is that they can be tolerated by any civilized community. They probably would not be allowed to continue in operation if half of their iniquities were known to those who have unwittingly consumed the offensive products.

The very large abattoirs are not without some disadvantages. They cover so much ground and are divided into so many departments that it is difficult to keep the entire plant under supervision. Diseased meat should not be allowed to accumulate, because there are too many opportunities to remove it—too many places to which it can be taken and worked up without fear of detection. The killing floor is the proper place to intercept unwholesome meat. All meat must enter the abattoir through this channel, and here it can be carefully examined and all its defects discovered. There is one contingency which it is difficult to guard against even here, and that is the slaughtering of animals outside of the regular hours, or even in the middle of the night, without the inspector's knowledge. To prevent this, there should be a constant watch, and any company found to be offending in this way should be so severely punished that a repetition of the practice would not be likely to occur.

The Federal meat-inspection law does not apply to abattoirs which do a strictly local business, and consequently the inspection at such places can only be made by the municipal health authorities. In most if not all cities this service is very inadequate. The number of inspectors is not sufficient to maintain a proper supervision, and too frequently the inspectors are incompetent or entirely ignorant of animal diseases and the effect of these upon the public health.

When the meat-inspection service is sufficiently extended so that the provision of the law requiring all meat to be inspected which is transported from one State into another can be enforced, there will be protection for all consumers who insist on being shown the tags and stamps which certify to this inspection. In the meantime there is much interstate meat which is not inspected, and the purchaser has no means of knowing the condition of the animals from which it was obtained. The importance of extending the inspection service rapidly and thoroughly until the whole country is embraced is too apparent to need argument. Until this is accomplished the large operators, who have the inspection, are benefited at the expense of the smaller ones, who are unable to obtain it, while the public receives but inadequate protection.

THE COST OF MEAT INSPECTION.

Before the inspection service was inaugurated it was supposed that the cost would be so great that the utility of the work would be called in question. The experience which has been gained demonstrates, however, that a thorough inspection may be made at a reasonable expense.

Before the inspection was commenced it was estimated that the microscopic examination would cost the Government about 25 cents per carcass. The first month of the inspection the cost was 20.3 cents per carcass, and this was reduced the second month to 13.3 cents and the third month to 8.6 cents. Since that time the amount of work put upon the specimens from each carcass has been nearly doubled in order to increase the reliability of the inspection; but by perfecting the system and improving the methods the cost has been still further reduced, and during the year just closed has been only 6.5 cents per carcass. This is about the minimum for which a thorough microscopic examination can be made.

The cost of the ordinary inspection of animals before and at the time of slaughter has varied considerably in different years. In the year ending June 30, 1893, it was $4\frac{3}{4}$ cents per animal, and during the last year was only $1\frac{3}{4}$ cents per animal. This great reduction of expense is partly accounted for by the large number of hogs examined, which require less time than cattle, and partly by modified methods which secured more work for the same expenditure.

The experience of the last year has demonstrated the possibility of maintaining a thorough and complete inspection of meats at an expense which would not be felt by the consumer. The microscopic examination of pork has cost less than one-twentieth of a cent per pound, while the ordinary inspection has not cost one one-hundredth of a cent per pound. Would not every consumer prefer to pay this additional cost and purchase only inspected meat? It is probable that there is nearly a unanimous sentiment in the affirmative. How, then, can this expense be assessed against the consumer in an equitable manner?

It has been proposed to require the packers to pay this expense by charging them a fixed amount for every tag that is attached to the meat and for every stamp that is affixed to a package. It is only reasonable to suppose that the packers in turn would add this expense to the selling price of the meat, and that the consumer would finally have it to pay.

The consumer ought not to object to paying the very small additional sum which is required to inspect meat according to the system now in operation, as the protection afforded would be worth much more to him than the cost. The difficulty would be to prevent the great corporations which control the meat business from exacting much more from the consumer than they had been compelled to pay to the Government. Let us suppose, for example, that the Government charges the packer one-twentieth of a cent a pound for the pork inspection; would not the packer make this an excuse to charge one-fourth of a cent a pound additional to the dealer, and would not the result be that the consumer who buys only 1 or 2 pounds at a time would be charged 1 cent a pound more than formerly? The consumer, then, instead of paying the exact cost of the inspection, which would be insignificant to him, would be

taxed twenty times this cost, and consequently would be unfairly treated. Nineteen-twentieths of what he would pay for inspection would go to increase the profits of the packers and retailers of meat. We are warranted in concluding that this example is not far from what would actually occur by a consideration of the methods which the gentlemen who control this business have enforced in the past.

The problem is, therefore, how to collect the cost of inspection from the consumer, which practically means every citizen of the country, with the least expense for the collection.

The reduction in the cost of the microscopical inspection as compared with the quantity of microscopically inspected pork actually exported has been very gratifying. During the fiscal year 1893 there were exported 20,677,410 pounds of inspected pork, and the cost of the inspection amounted to $172,367.08, or 0.833 cent for each pound exported. For the fiscal year 1894 the quantity exported was increased to 35,437,-937 pounds and the cost of inspection reduced to $88,922.10, or 0.248 cent for each pound exported.

A similar statement concerning the first and second halves of the last fiscal year shows that this reduction in the cost of the microscopical inspection as compared with the quantity of pork exported was progressive throughout the year, and reached a much lower limit than is indicated above. That is, from July 1, 1893, to December 31, 1893, the quantity of inspected pork exported was 12,618,706 pounds and the expense of the microscopic inspection was $53,433.68, or 0.42 cent for each pound exported, while from January 1, 1894, to June 30, 1894, the quantity of inspected pork exported was 22,819,231 pounds and the cost of inspection was $35,488.42, or 0.155 cent for each pound exported. In other words, the microscopic inspection now costs the Government only 1 cent for each 6½ pounds of such inspected pork which is shipped to foreign countries.

THE IMPORTANCE OF MEAT INSPECTION.

There are few citizens of the country who realize the importance of a rigid inspection of meats by competent inspectors. In the days when animals were killed by the local butcher, whose reliability could be determined, and who was generally known to the consumer, there was not the same reason for suspicion as to the quality of meat which exists at present. To-day the essential work in the preparation of meats is conducted at a distance from the producer of the animals, and at an equal distance from the consumer of the products.

The man who ships animals to these distant markets knows that their identity will in most cases be lost when they mingle with the enormous number of animals of the same species which arrive each day at any of the great stock yards of the country. He therefore has not the reason for hesitation in shipping hogs infected with cholera, cattle with actinomycosis or tuberculosis, and sheep with any of the diseases to

which they are subject which he would have in trying to sell such animals for slaughter and consumption in the neighborhood where he is known.

At the stock yards we find the commission man, who desires to get the best prices which he can obtain for the animals which have been consigned to him, and also the buyer for the packing houses, who desires to purchase as cheaply as possible. There is consequently an incentive for every man who handles the animals to use his influence to have them passed and used for the purposes which yield the best returns. The owners of the packing houses do not see the animals themselves, and would know very little about them in case they did. Each department of business is in charge of a superintendent, whose standing with the firm is probably rated by the success of his department—that is, by the money which he is able to make for the corporation. The products go to the consumer, often in distant parts of the land; frequently the identity of the goods is lost, and the final purchaser has no idea who slaughtered the animals from which they were produced, or even the city in which the slaughtering and curing was effected.

Under these circumstances both the identity and responsibility of the principal parties to the transaction are lost. If the meat affects the health of the consumer, it is for the most part impossible to determine whether this was on account of the animal being diseased, or because of improper curing, or carelessness in handling by the shipper or retailer. If the packer could be identified he would generally be able to shift the responsibility upon the retailer. or at least to make his share of it uncertain.

The cases are comparatively rare in which any disease affecting an animal is transmitted through the meat to the consumer. Anthrax is the most dangerous malady in this respect, because the germs circulate with the blood and reach every portion of the body. They are certain to be in every particle of meat taken from the carcass. To make the matter worse, the germs of anthrax form spores when the carcass is dressed and the oxygen of the air comes in contact with the meat. These spores resist a very high temperature and may not be destroyed by cooking. There are instances on record of great mortality following the consumption of carcasses affected with this disease. Fortunately, anthrax is rare in the United States, and the affected animals die so quickly after infection that there is not much chance that they will reach the abattoirs alive.

The germs of tuberculosis, as a rule, are not found in the muscular tissues, and they are more readily destroyed by heat. While there are many tuberculous cows all over the world, the danger from the meat of such animals is not as great as is generally supposed, particularly if it is fairly well cooked.

Glanders of the horse is a disease which in the characteristics mentioned resembles tuberculosis. When old, worn-out horses are gath-

ered from all parts of the country for slaughter, it is morally certain that some of them will be affected with this disease. The slaughter of these animals without inspection is, therefore, a nuisance to the community and should be prohibited.

Anthrax, tuberculosis, and glanders are three diseases of animals communicable to man, and from which he has little chances of recovery. There should, consequently, be every precaution enforced to protect the consumer from meat infected with such contagion.

Trichinosis of hogs is also a terrible and fatal disease, which, while not as common in this country as in Germany, still occurs in far too many cases. The consumer may protect himself absolutely from this disease by requiring all pork to be thoroughly cooked before it is eaten. Curing also destroys the vitality of the parasite, so that it is rarely that cases are found which have originated from eating salted pork. The cases of trichinosis in man which have occurred in this country have generally resulted from pork killed in some small local slaughter-house or on the farm. Packing-house pork has seldom been accused of causing the trouble. The reason, of course, is that pork from the packing houses is generally salted and is cooked before it is eaten, while that killed locally is frequently eaten fresh and often without being sufficiently cooked, sometimes without being cooked at all.

Were it not for our large German population, trichinosis would hardly be worthy of consideration as a sanitary question. As it is, however, cases are reported from time to time, and the terrible suffering of the victims, together with the high death rate, makes it desirable to adopt, if possible, preventive measures. The microscopic inspection of all the pork prepared at the abattoirs doing an interstate trade would prevent a portion of these cases; but beyond giving consumers an opportunity to select pork free from the parasite it would probably be disappointing.

The elaborate and expensive system of microscopic inspection adopted by Germany has not fulfilled expectations, as the number of cases of trichinosis which occur from inspected pork is so large that it rather indicates the unreliability of the method than inspires confidence in it as a prophylactic measure.

There are many other diseases liable to affect animals as they arrive in the stock yards which, while not directly communicable to mankind, may, nevertheless, produce serious or even fatal illness in those who consume the meat. Animals are frequently injured in transit, and as a result may become affected with gangrene, septicæmia, pyæmia, malignant œdema, peritonitis, or metritis, any of which conditions make the flesh absolutely unfit for food and dangerous to the health of consumers. In other cases there may be abscesses or actinomycotic tumors, the effect of which upon the carcass depends upon the extent of the lesions.

It is not uncommon to find animals in a feverish condition owing to

bruises, local inflammations, or other causes. If the fever is very pronounced the carcasses should be condemned. In most countries such carcasses as these would be allowed to go upon the market, because no special disease has been traced to them. In the United States, however, the people object to the flesh of animals affected with any disease which deranges the important functions of the body, and while there is such an abundant supply of healthy animals this sentiment should be respected. The flesh of feverish animals undoubtedly contains an abnormal quantity of leucomaines and in many cases of toxins, which are liable to affect the digestive organs, particularly in hot weather, and to cause illness, which is mild or serious according to the condition in which the consumer happens to be at the time he partakes of it.

The flesh of animals which have recently given birth to their young is objected to for the same reasons as is that from animals in a feverish condition. Animals shipped in this condition are very liable to inflammation of the uterus and septic infection, and should on no account be passed as fit for human food. Animals in advanced pregnancy are very subject to injury during shipment. They often abort if allowed to remain a few days in the stock yards, and it is not uncommon to find a dead and partly decomposed fetus in the uterus. Even when uninjured, animals almost at the period of parturition can not be considered as furnishing acceptable meat. The nutriment which they assimilate is diverted from their own tissues to sustain the fetus, while the waste products of the latter's vital activity increase those already present in the mother's circulation. The meat from such animals may not usually cause disease in the consumer, but its nutritive qualities are impaired, and there is good reason for the repugnance which the American people feel in regard to it.

These conditions and many others are daily met with in the animals shipped to the large cities for slaughter. To determine the exact condition, the nature of the disease, and the proper disposition of the carcass requires expert veterinary knowledge. The inspectors should be not only competent but thoroughly honest and reliable. There should be stringent, clearly defined laws and rigid regulations from which the inspector will know his duty, and by which he will be able to dispose of diseased or unwholesome meat without being annoyed by constant appeals made by interested parties.

VESSEL INSPECTION.

The vessels carrying the exported cattle and sheep are all inspected by the officers of this Bureau in accordance with the act of Congress approved March 3, 1891, in order to secure sufficient ventilation, an adequate supply of food and drinking water, competent attendants, fittings sufficiently strong to avoid unnecessary danger of washing overboard, and enough space for the animals to stand in with comfort.

The regulations adopted in 1891 are still in force, but they have been amended from time to time, and the condition of the cattle in transit has been continually improved.

This improvement is shown by the marked decrease in the proportion of cattle lost at sea. The loss for each year since the regulations went into effect was as follows: 1891, 1.6 per cent; 1892, 0.875 per cent; 1893, 0.47 per cent, and in 1894, 0.37 per cent.

The loss of sheep has been much heavier. Of the 80,898 exported and shipments inspected in Great Britain during the fiscal year 1,050 were lost at sea. This is 1.29 per cent, and it indicates that more stringent regulations must be enforced to secure the humane treatment of these animals on shipboard.

STOCK-YARDS INSPECTION.

An inspection at a number of the important stock yards of the country is maintained for the purpose of inspecting and tagging export cattle as near to their place of origin as is possible. After being tagged and recorded there is a supervision of the shipments, in order to prevent infection of any kind on the way to the seaboard.

In the past one of the greatest dangers during the summer months has been infected pens in the stock yards, or infected alleys, streets, or cars which have been contaminated by cattle from the Southern fever district. These cattle, though apparently healthy, may so thoroughly infect the avenues through which they pass that they will be deadly for other cattle during the remainder of the season.

It has therefore been found necessary to set apart separate pens and alleys for these Southern cattle, to prohibit their exportation, and to disinfect the cars in which they have been shipped. To secure the enforcement of these regulations constant supervision and inspection must be maintained, for otherwise infected cattle would be allowed to enter the pens in which export cattle were handled, and this would do away with any possible chance of guarding against the infection.

The stock-yards inspection is designed to guard against the Southern fever infection, but it also embraces the inspection and tagging of export animals and the inspection of the vessels which carry them. These different lines of inspection are so closely allied that they can not be separated without detriment to the service and increased expenditures. It should be borne in mind, however, that the entire expense of the stock-yards inspection is not for the benefit of the export trade, but that the cattle which are to remain in this country, more particularly the "feeders," are also protected.

The losses from the Southern or Texas fever have been almost entirely prevented, and cattle may now be moved through our largest stock yards without danger, while before the inspection was inaugurated a large part of the cattle so handled became infected.

This inspection, as it only continues during the spring, summer, and fall months, is reported for the calendar instead of the fiscal year. In the quarantine season extending from February 15 to December 1, 1893, there were inspected and placed in the quarantine pens 1,737,380 head of cattle. In addition to this the inspectors had 56,406 cars cleaned and disinfected under their supervision, and inspected 20,075 car loads of infected cattle which were en route for places beyond their jurisdiction.

INSPECTION IN GREAT BRITAIN OF ANIMALS FROM THE UNITED STATES.

This inspection has been continued during the year by two inspectors, one being stationed at London and the other at Liverpool. The object of this inspection is to learn the condition in which animals arrive, the extent of the losses at sea, the diseases with which animals in transit are affected, or from which they die, and the adequacy of the ventilation and fittings of the vessels for the safe transportation of their living freight.

This information can only be obtained from the representatives of this Bureau who examine the animals both before and after they are unloaded from the ships. By means of this information improvements have been made by which the losses at sea have been reduced from 1.6 per cent the first year of service to 0.37 per cent during the last fiscal year. This means a saving of 4,470 head of cattle on the exports of the last year. How much was saved by the regulations of the first year over the unregulated trade we have no data to determine, but it probably was a still larger number.

The British restrictions have not yet been removed from our cattle trade, but with the continued freedom of the United States from pleuro-pneumonia and other contagious diseases dangerous to the stock interests of that country it is probable that reasonable modifications will be made.

The entire expenses of the stock-yard, vessel, and export animal inspection for the year was $96,707.44. At least half of this expense is for the prevention of Texas fever in this country, and should not be charged against the export inspection. This would give an expenditure of about 10¾ cents for each animal exported. Considering that this covers the tagging of every animal and two inspections in the United States and one in Great Britain for the greater part of them, as well as inspection of the ships and supervision of the loading, it is seen that the service is very economically performed.

Following this estimate to its legitimate conclusion, we find that the $48,353.72 which we estimate was expended in inspecting and quarantining 1,737,380 head of cattle from the district infected with Southern or Texas fever makes the cost of such inspection 2.7 cents per animal, with no allowance for the disinfection of 56,406 cars.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

The number of animals imported from Europe, inspected and quarantined on arrival, was 11 head of cattle, 565 sheep, 43 hogs, and 4 goats quarantined at Garfield, N. J., and 1 head of cattle and 179 sheep quarantined at Patapsco, Md. In addition, 3 head of cattle imported from Canada were quarantined at Buffalo, N. Y. This makes a total of 806 imported animals that were quarantined during the year.

Under the provisions of the act of Congress approved August 30, 1890, requiring the inspection of all cattle, sheep, and hogs imported into the United States from foreign countries, there were inspected, as imported from Canada, 194 head of cattle, 240,497 sheep, 1,302 hogs, and 2 goats.

Cattle from Europe and Canada are still detained in quarantine for a period of ninety days, which is necessary to protect from the contagion of pleuro-pneumonia, with which most European countries are still infected. Sheep from Europe are detained fifteen days, a period considered sufficient to guard against the introduction of foot-and-mouth disease; if from countries on the American continent, these animals are admitted on inspection when found free from any form of contagious or infectious disease.

EDUCATION AND RESEARCH IN AGRICULTURE IN THE UNITED STATES.

By A. C. True, Ph. D.,

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More than a century has elapsed since the movement began in this country to advance the interests of agriculture by widening the information of the farmer regarding the rational practice of his art. Near the end of the eighteenth century there was unusual activity in agricultural affairs, both at home and abroad. New crops and breeds of animals were being introduced. The attention of practical men was drawn to the discoveries of science, and great hopes were excited that immediate benefits of inestimable value would accrue to agriculture as well as to the other arts, especially from the application of the principles of chemistry to the various industries. The newly awakened interest in the oldest of human occupations was marked by the formation of agricultural societies. In Great Britain, for example, the Bath and West of England Society and the Highland Society were established. The British Government also recognized the importance of the movement by organizing a board of agriculture. The same influences were soon felt in the New World.

ORIGIN AND DEVELOPMENT OF AGRICULTURAL INSTITUTIONS IN THE UNITED STATES.

As far as is now known, the first society for promoting agriculture in the United States was established at Philadelphia, then the seat of the General Government, March 1, 1785, by men who were for the most part engaged in pursuits having no immediate connection with agriculture. On the 4th of July, 1785, General Washington was elected an honorary member of this society and ever afterwards showed a deep interest in its proceedings. Benjamin Franklin's name is also found on the list of its honorary members. In the same year a similar society was formed in South Carolina, which had among its objects the establishment of an experimental farm. This society was incorporated December 19, 1795. The present State Agricultural Society of South Carolina still holds the original charter. The New York Society for the Promotion of Agriculture, Arts, and Manufactures was organized February 26, 1791, and about the same time a society was formed at Kennebec, Mass. (now Maine). In 1792 the New York society published a small quarto volume of its transactions. The Massachusetts

Society for Promoting Agriculture was incorporated March 7, 1792, and in 1794 the Western Society of Middlesex Husbandmen was formed in Massachusetts, though not incorporated until 1803. "The Society for Promoting Agriculture in the State of Connecticut was organized August 12, 1794, and published its first volume of transactions, a small quarto pamphlet, in 1802." This society still exists as the county society of New Haven.

THE FIRST PLANS FOR AGRICULTURAL EDUCATION.

In 1792 Samuel L. Mitchill, M. D., LL. D., was appointed professor of natural history, chemistry, agriculture, and the other arts depending thereon, in Columbia College, in the city of New York. The college records do not show whether he ever gave any instruction in agricultural subjects, but it is almost certain that he was active in early efforts to advance agriculture through education, and that men afterwards prominent in urging the establishment of agricultural colleges were among his students. Lavoisier, who was probably the first scientist to give systematic attention to the application of chemistry to agriculture, was then the great chemist. Dr. Mitchill is credited with introducing his theories in this country, and undoubtedly referred in his lectures to the agricultural features of this science. We know that he was active in the New York Society for the Promotion of Agriculture, Arts, and Manufactures, and that he wrote essays on the chemistry of manures. He was retired in 1801, having been elected a member of the House of Representatives.

On the 21st of January, 1794, a committee was appointed by the Philadelphia society "to prepare outlines of a plan for establishing a State society for the promotion of agriculture, connecting with it the education of youth in the knowledge of that most important art, while they are acquiring other useful knowledge suitable for the agricultural citizens of the State." The committee made a report in which several alternatives for promoting agricultural education are presented to the legislature:

> Whether by endowing professorships, to be annexed to the University of Pennsylvania and the College of Carlisle, and other seminaries of learning, for the purpose of teaching the chemical, philosophical, and elementary parts of the theory of agriculture; or, by adding to the funds of the society, increase their ability to propagate a knowledge of the subject, and stimulate, by premiums and other incentives, the exertions of the agricultural citizens; or whether, by a combination of these means, the welfare of the State may be more effectually promoted.

It was also a part of the plan to make the common-school system of the State contributory to the technical education of the farmer.

> The country schoolmasters may be secretaries of the county societies, and the schoolhouses the places of meeting and the repositories of their transactions, models, etc. The legislature may enjoin on these schoolmasters the combination of the subject of agriculture with the other parts of education. This may be easily effected by introducing, as school books, those on this subject, and thereby making it familiar

to their pupils. These will be gaining a knowledge of the business they are destined to follow, while they are taught the elementary parts of their education. Books thus profitable to them in the common affairs of life may be substituted for some of those now used, and they can easily be obtained. Selections from the best writers in husbandry may be made by the society. The essays of our own experimentalists or theorists and the proceedings of the society will also afford information.

This report seems to have been the first formal attempt made in the United States to urge the claims of agricultural education and experimentation upon the attention of a lawmaking body.

WASHINGTON'S MESSAGE TO CONGRESS.

Two years later, on December 7, 1796, in his annual message to the second session of the Fourth Congress, Washington showed his interest in agriculture by the following recommendation:

It will not be doubted that, with reference either to individual or national welfare, agriculture is of primary importance. In proportion as nations advance in population and other circumstances of maturity this truth becomes more apparent and renders the cultivation of the soil more and more an object of public patronage. Institutions for promoting it grow up supported by the public purse, and to what object can it be dedicated with greater propriety? Among the means which have been employed to this end none have been attended with greater success than the establishment of boards composed of public characters, charged with collecting and diffusing information, and enabled, by premiums and small pecuniary aid, to encourage and assist a spirit of discovery and improvement. This species of establishment contributes doubly to the increase of improvements, by stimulating to enterprise and experiment, and by drawing to a common center the results everywhere of individual skill and observation, and spreading them thence over the whole nation. Experience accordingly has shown that they are very cheap instruments of immense national importance.

I have heretofore proposed to the consideration of Congress the expediency of establishing a national university, and also a military academy.

Congress soon established the academy to promote the science and art of war, but paid no attention to the words of the great general in favor of institutions to benefit the sciences and arts of peace.

In 1797 the trustees of the Massachusetts society began the publication of pamphlets, or, as we should now say, bulletins, on agricultural topics, which afterwards were developed into a regularly issued journal. A voluntary agricultural association was formed at Stockbridge, Mass., in 1799, and probably a few other societies were organized before the close of the last century.

Near the opening of the new century (1801) a suggestion was made to the Massachusetts society that fairs should be regularly held in May and October on Cambridge Common and bounties given for certain articles. This plan included not only the exhibition of agricultural products, but also stated open markets for their sale. No action was taken by the society regarding this suggestion. In the same year this society discussed a proposition for the permanent endowment of a professorship of natural history and a botanic garden at Harvard

College. The society took a lively interest in this matter and was enabled to carry out the suggestion in 1804, when William D. Peck was elected to fill the new chair.

AGRICULTURAL FAIRS AT WASHINGTON.

In the Report of the United States Commissioner of Agriculture for 1866, in an article on the History of the Agriculture of the United States, by Ben: Perley Poore, may be found the following statements regarding the first attempt made at the newly established seat of the National Government to promote the interests of American agriculture:

In 1804 it was suggested by Dr. Thornton, the first Commissioner of Patents, then residing in Washington, which was literally a "city in the woods," that the ready sale of cattle and of domestic products could be promoted by the holding of fairs on market days, as in England, his native land. The idea met with the warm approval of the citizens, and the municipal authorities passed an act establishing semiannual fairs. An editorial article in the National Intelligencer of October 17 spoke of the coming fair as offering advantages to purchasers and to settlers, "while at the same time it can but prove equally beneficial to the agricultural interests of our country." The fair was held on Wednesday, Thursday, and Friday, in "the mall at the south side of the Tiber, extending from the bridge at the Center Market to the Potomac."

It was a decided success, and before the next one was held an attempt was made by additional legislation on the part of the city government to increase its usefulness by appropriating $50 toward a fund for premiums. The citizens raised by subscription an equal sum, so that at the fair, which began on the 26th of April, 1805, premiums to the amount of $100 were awarded to the best lamb, sheep, steer, milch cow, yoke of oxen, and horse actually sold. A third fair was held in November, 1805, after which they were discontinued.

Early in the year 1806 Joel Barlow, then residing at Kalorama, in the vicinity of Washington, published the prospectus of a "National Academy," in which he enumerated, among the foreign institutions to be copied in forming an American organization, the agricultural societies of England and the veterinary school of France.

Meanwhile an institution had been organized by "members of Congress, officers of the Federal Government, and others, devoted to objects connected with public economy." Meetings were held at Mr. Hervey's, on Pennsylvania avenue, every Saturday evening, from 5 until 8 o'clock, and among the subjects considered were:

Our mechanical economy, or the means of abridging labor by useful inventions, implements, and apparatus; our agricultural economy, or the means of producing the most abundant and most reciprocal crops, under any given circumstances, without doing things by guess; the economy of our forests, or the best management of our latent resources there.

CATTLE SHOWS IN MASSACHUSETTS.

In the autumn of 1807 Elkanah Watson, a native of Plymouth, Mass., and a direct descendant of Governor Edward Winslow, who, in 1624, had brought to Plymouth, in the ship *Charity*, three heifers and a bull, "the first neat cattle that came into New England," procured the first pair of Merino sheep which had been introduced into Berkshire County, and gave notice of an exhibition of his two sheep on the public square at Pittsfield. He wrote that "many farmers and even females were attracted to this first novel and humble exhibition." The interest

excited by this exhibit led Mr. Watson to undertake a larger enterprise, and on the 1st of August, 1810, an appeal drawn by himself and signed by twenty-six persons was published, appointing an exhibition of stock at the same place on the 1st of October. This "cattle show" was quite successful, and before many years the annual exhibit became a permanent and popular institution in Massachusetts. Mr. Watson's report of the exhibition of September, 1811, shows the picturesque elements which were thus early introduced into these rural festivals. There was "a procession of sixty-nine oxen drawing a plow held by the oldest man in the county; a band of music; the society, bearing appropriate ensigns, each member decorated with a badge of two heads of wheat in his hat, and the officers three heads secured by a green ribbon." Meanwhile, in 1809, a number of gentlemen interested in agriculture, residing in Maryland, Virginia, and the District of Columbia, had formed the Columbian Agricultural Society, which may properly be considered as the germ of a national organization. This society actively engaged in the work of educating the farmer through the agency of exhibitions.

HINDRANCES TO AGRICULTURAL EDUCATION, 1810–1840.

Various causes seem to have contributed to retard the progress of agricultural education during the next three decades. The war with England, from 1812 to 1815, undoubtedly turned the attention of our people away from the consideration of measures for the improvement of agriculture. The obstruction to commerce growing out of the wars of Napoleon, and the quarrel between England and the United States, caused the manufactures of this country to develop with wonderful rapidity. The enterprising youth were drawn in large numbers from the farms to factories, and the public mind was occupied with schemes for increasing the wealth of the country in this direction. However, in 1817, the Berkshire Agricultural Society of Massachusetts, under the enthusiastic leadership of Elkanah Watson, presented a memorial to Congress praying for the establishment of a national board of agriculture, in accordance with the original suggestion by President Washington. A bill for this purpose was actually reported in the House of Representatives, but was defeated by an overwhelming vote. Some members opposed the bill because there was in their judgment no warrant in the Constitution for such an institution; others based their opposition on questions of expediency, or on the general indifference of the agricultural public. It was also well known that President Madison was not in favor of the measure. The decade closed with the establishment of the New York Horticultural Society, the first horticultural society in the United States, in 1818, and the publication of the first distinctively agricultural periodical in this country, the American Farmer, in Baltimore, Md., in 1819. This was followed by the New England Farmer, published in 1822. "During this decade, also, the

wool interest made much stir. The breaking up of the flocks in Spain, the importation of Merino sheep into this country, and the speculation which followed, influenced agricultural fairs and societies."

There were comparatively few events of striking interest to mark the progress of agriculture in the United States during the next twenty years. During this period the boundaries of the Republic were greatly enlarged; the introduction of steam as a motive power was already contributing largely to the movement of population from worn-out lands in the East to fertile districts further west; the demoralization of enterprise resulting from the employment of slaves was beginning to be felt in the South; questions relating to the extension of slavery, to methods of transportation, to the establishment of new States and Territories, to public systems of free elementary education, were absorbing public attention. There was little heed paid to the claims of scientific agriculture or thought about the necessity for technical education. About 1825, however, there was considerable popular interest in a scheme for the culture and manufacture of silk in the United States, a matter which had had its cycles of agitation somewhere in this country in every decade since 1750. Congress responded to the demand for information by ordering the publication of a well-digested manual prepared by Richard Rust, Secretary of the Treasury, containing the best practical information that could be collected on the growth and manufacture of silk. In 1828 an edition of a Treatise on the Rearing of Silkworms, by Count Von Haggie, of Munich, was printed as a Congressional document, and several valuable reports on silk culture were made and published, until the bursting of the "Morus multicaulis bubble" checked for a time this branch of agricultural industry.

REVIVAL OF INTEREST IN AGRICULTURE.

Ten years later public attention was rudely awakened to the necessity of doing something to prevent the rapid exhaustion of the soil, which was becoming a matter of serious concern in all States along the Atlantic seaboard. The failure of the crops in 1837–38 turned the balance of trade heavily against us and caused the importation of millions of dollars' worth of breadstuffs. From this time may be dated the beginning of active interest in agriculture on the part of the National Government. At the prompting of Hon. Henry L. Ellsworth, Commissioner of Patents, Congress, in 1839, made an appropriation of $1,000 for the "collection of agricultural statistics, investigations for promoting agricultural and rural economy, and the procurement of cuttings and seeds for gratuitous distribution among the farmers." In the two succeeding years Congress failed to make any further appropriation, but the Commissioner of Patents did not flag in his efforts to secure recognition of the claims of the farmers by the National Legislature, and in 1842 the appropriation for agriculture was renewed and has ever since been regularly made, except in 1846. The first attempt

to organize a national agricultural society was made at Washington in 1841 by a convention of persons desiring "to elevate the character and standing of the cultivation of the American soil." It was hoped that the fund left by Hugh Smithson might be made available for the maintenance of such an organization, but the establishment of the Smithsonian Institution frustrated these expectations, and the "national society remained dormant until 1852."

PLANS FOR AGRICULTURAL EDUCATION IN NEW YORK AND OTHER STATES.

The history of the early agitation in favor of agricultural education in the State of New York is very interesting and instructive. Prof. W. H. Brewer, of Yale University, who was closely identified with agricultural schools established in that State prior to 1860, has collected much information on this subject, and the author of this article is indebted to him for many of the facts here stated. As early as 1819, Simeon De Witt, surveyor-general of New York, to whom we are indebted for the classical names given to many towns in that State, in a pamphlet published anonymously at Albany, under the title "Considerations on the necessity of establishing an agricultural college," urged the foundation, under State authority, of an institution which he proposed to call "The Agricultural College of the State of New York." This matter was thereafter never allowed to drop wholly out of sight. Allusions to an attempt to found an agricultural college in 1822 are found in the Transactions of the New York Agricultural Society and elsewhere.

In 1826 mention is made of a lyceum in Maine devoted to agricultural studies, of schools in Connecticut having agricultural courses, and of efforts in Massachusetts to establish an agricultural college. The Farmers' School Book, by Prof. J. Orvill Taylor, was published at Ithaca, N. Y., in 1837. It was a little elementary work on science, particularly chemistry, on the use of manures and on general farming, and was soon introduced in many of the district schools. About the same time the establishment of an agricultural college, probably a private speculation, was undertaken in Columbia County. Between 1830 and 1840 there was much talk about "manual labor schools," a term variously applied to schools in which the students were to pay for their education in whole or part by their labor, and a number of schools were started on that basis. The Oneida Institute was one of the earliest of these schools, and for a time enjoyed considerable popularity. So general had the agitation for agricultural education become in New York by 1838 that petitions asking for State aid in behalf of this cause, with nearly 6,000 signatures, were presented to the legislature and turned over to a committee, who made a report deploring in strong language "that there is no school, no seminary, no subdivision of any school in which the science of agriculture is taught," and recom-

mending the establishment of a school for this science. This matter came up in the legislature in different forms in succeeding years, and the movement seems to have steadily grown in strength and importance. It was greatly aided by the State Agricultural Society, which was reorganized in 1841, and immediately began the publication of the series of volumes of Transactions, which was continued annually for over thirty years, and less frequently since. One project of these times was that the State should maintain a lecturer who should inform the people of different localities on scientific and practical agriculture. Lectures on agricultural chemistry were delivered about this time to popular assemblies or schools in western New York, and this seems to have been done elsewhere, perhaps as far south as Georgia.

At the annual meeting of the New York State Agricultural Society in January, 1844, a committee of seven, consisting of Hon. John Greig, Governor Seward, Lieutenant-Governor Dickinson, Col. John A. King, James S. Wadsworth, Judge Savage, and Henry O'Reilly, was appointed to promote "the introduction of agricultural books and studies in the schools and libraries throughout the State, and also for the purpose of selecting such prize essays from among the transactions of the society as may be most appropriately published in volumes of suitable size for the family and school district libraries;" and the society further resolved "That this society regards the establishment of an agricultural institute and pattern farm in this State, where shall be taught thoroughly and alike the science, the practice, and the profits of good husbandry, as an object of great importance to the productive agriculture of New York."

This committee entered into correspondence with school superintendents and influential friends of agriculture in several States and presented an elaborate report the following year, in which are quoted the resolutions passed by the State convention of common-school superintendents held in June, 1844. The chairman of the committee which submitted these resolutions was Professor Potter, of Union College, and the committee stated that in their opinion "the time has arrived when the elements and scientific principles of agriculture should be taught in all our schools, especially to the older class of pupils."

Between 1845 and 1850 agricultural schools were established by private enterprise in various places in the State. Among the peculiar features of these earlier schools were courses of lectures on agricultural chemistry and other topics, similar to the short or winter courses recently organized in a number of our agricultural colleges. For example, the Genesee Farmer for March, 1846, speaks of the Cortland County Agricultural School and of Mr. Woolworth's "unexpected success" in delivering lectures once a week to twenty-five or thirty farmers.

The agricultural school at Cream Hill, Connecticut, was established in May, 1845, by Dr. S. W. Gold and his son, T. S. Gold, and continued in successful operation until 1869. The number of pupils was limited to 20, and the object of the school was "to unite with classical and scientific education, theoretical and practical instruction in agriculture."

A course of lectures on agricultural chemistry was delivered in New Orleans on invitation of citizens during the winter of 1845–46, by B. W. Jones, afterwards a professor in Yale College.

Sufficient interest was awakened in this and other plans for the promotion of agriculture to make it seem to the United States Commissioner of Patents worth while to send a special agent to Europe to investigate the movements there in the same direction. In the report of this agent, published in 1847, is contained an account of the European agricultural schools.

In 1846 John P. Norton was appointed professor of agricultural chemistry and vegetable and animal physiology at Yale College, New Haven, Conn. B. Silliman, jr., was appointed professor of chemistry applied to the arts. This was the beginning of Sheffield Scientific School. The Lawrence Scientific School at Harvard was begun about the same time. Professor Norton began his lectures in 1847, and during the next five years also wrote extensively for agricultural journals, edited an American edition of Stevens on the Farm, and published a work of his own on the Elements of Agriculture. So great was the demand for teachers in agricultural chemistry that a regular course with a view to their preparation was established at Yale in 1848. Prof. W. H. Brewer was among the first students to take this course, and Prof. S. W. Johnson joined him in 1849.

In January, 1849, Governor Hamilton Fish, of New York, in his annual message to the legislature of the State, strongly recommended the establishment of a State agricultural college. The same year the New York Agricultural Society established at Albany a chemical laboratory for the analysis of soils, manures, etc., and an elaborate but very inaccurate chemical examination of maize was made there by Dr. Salisbury. During the session of the legislature that year Professor Johnston, of Edinburgh, the celebrated Scotch agricultural chemist, came to Albany and delivered a course of lectures under the auspices of the society.

In an address before the Norfolk Agricultural Society, delivered in 1849, Hon. Marshall P. Wilder urged the advisability of establishing an agricultural college in Massachusetts. The idea speedily took hold of the friends of agriculture in that State to such an extent that in 1850 the State senate of Massachusetts passed a bill to found such an institution, but it was defeated in the house. As a compromise measure a board of commissioners was appointed to investigate the matter. The commissioners sent Professor Hitchcock to Europe to visit the agricultural schools already in operation there, and his report was transmitted to the legislature in the following year. The only immediate outcome of this movement was the establishment of the Massachusetts Board of Agriculture in 1852.

The United States Commissioner of Patents had meanwhile begun to urge upon Congress the desirability of giving national aid to agricultural education. In his report for the year 1850 he deplores the lack of

qualified men to fill professorships in agricultural colleges, and says that "if a young farmer engaged in stock growing wishes to study the digestive organs, the muscles, nerves, or blood vessels of the horse, cow, sheep, or hog, there is not a museum in all America where this can be done." And in the two succeeding years the same official publishes in his reports letters from prominent agriculturists urging the establishment of a national school for the training of teachers for agricultural and other industrial schools.

Professor Brewer thus writes concerning the first industrial college established in New York:

> In 1850 Mr. John Delafield, a retired banker of New York City, a graduate of Columbia College, where he may have received instruction from Professor Mitchill, was living on one of the best farms in the State, "Oaklands," near Geneva, in the town of Fayette, Seneca County. He was enthusiastic in all matters relating to agricultural progress, and was a near neighbor of John Johnston, the famous Scotch farmer, the pioneer of tile drainage in the United States. Mr. Delafield imported the first tile-making machine in 1852. He was also at one time president of the New York State Agricultural Society, and originated and carried out an agricultural and topographical survey of Seneca County. He took a deep interest in the cause of agricultural education, and, owing to his action and energy, on April 15, 1853, the State passed an act establishing a State agricultural college. This act created a board of ten trustees, of which Mr. Delafield was president, but appropriated no money. The college was to be located on Mr. Delafield's farm, in the town of Fayette, but as he died October 22 of the same year, nothing more was done about building a college there.

At this time the Ovid Academy, located some 15 miles south of Fayette, was in successful operation; agricultural chemistry was there taught, and public lectures were given upon the same subject. Rev. Amos Brown, the principal of that academy, conceived the idea of having the college charter transferred to Ovid. The agitation for this was begun in 1855, and in 1856 an act was passed providing for the loan by the State of $40,000 for twenty-one years without interest, and the citizens of the vicinity subscribed nearly $50,000 more for the carrying out of the plan. In that year the board of trustees was reorganized, and soon after a farm was purchased at Ovid and Judge Cheever was made president. Buildings were built and the college was formally opened as the New York State Agricultural College in the fall of 1860, under the presidency of Maj. M. R. Patrick. By this time the institution was heavily in debt, the civil war soon broke out, Major Patrick was called to the army, and the college was closed, never again to be opened as a school. The land and buildings reverted to the State and are now used for an insane asylum.

Contemporaneous with this was the starting of another institution, known as "The People's College," to be located near Havana, N. Y. It, too, was to be an industrial institution, but of wider scope. Its act of incorporation was passed April 12, 1853, or three days before that of the agricultural college just mentioned. Amos Brown later became the president of this institution, and as such took an active part in the

discussion of the Morrill bill, and was largely instrumental in securing its passage. In a letter dated December 1, 1862 (only five months after the passage of the bill), Mr. Morrill writes as follows:

> The Reverend Amos Brown took such active part in securing the passage of the bill referred to whenever it was before Congress, both by his earnest and intelligent advocacy of the measure through personal interviews and by sufficient urging the attendance of members on all questions of any test votes, his services continuing for months, that it is due to him and the institution of which he is the head, whenever an official disposition of the funds shall be made, that his merit shall not go unacknowledged by the State of New York. From an early moment after the first bill was introduced he has been unflagging in his efforts to promote the success of this great measure in behalf of agriculture, and it is a pleasure to me to acknowledge the value of his aid and cooperation.

It is interesting to note in this connection that even before the first introduction of the Morrill bill, in 1857, and when Mr. Brown probably had no knowledge of Mr. Morrill's intention to frame such a bill, Mr. Brown was earnestly urging that an agricultural college should be a broad institution of high grade, in which the sciences and technology should be taught along with the old studies. In talking of this matter he often expressed the sentiment, if not the very language, afterwards adopted for the seal of Cornell University.

After the passage of the Morrill act of 1862 the legislature of New York voted to give the whole of New York's share of the land grant to the "People's College," but afterwards, when that institution failed to comply with the conditions of the law, the grant was given to Cornell University.

THE FIRST AGRICULTURAL COLLEGE.

The constitution of the State of Michigan, adopted in 1850, requires that "the legislature shall provide for the establishment of an agricultural school for agriculture and the natural sciences connected therewith." In obedience to this provision an act for the establishment of a State agricultural college was adopted by the legislature of Michigan in 1855, and approved February 12 of that year, and the organization of the institution given into the charge of the State board of education. A farm, then in the woods, of 676 acres, lying 3½ miles east of the city of Lansing, was purchased and buildings erected, and on May 13, 1857, the college was formally opened for the reception of students. The institution began with 61 students and 5 professors. To Michigan, therefore, belongs the honor of having been the first of the States to put in actual operation an educational institution for the direct promotion of technical training in agriculture.

The Farmers' High School of Pennsylvania (now the Pennsylvania State College) was incorporated in 1854 and opened for students in February, 1859. Donations of land as a site for the institution were offered in several parts of the State. Funds for the erection and equipment of buildings were provided by the legislature, the State

Agricultural Society, and private subscription. The first president, Dr. Evan Pugh, had not only studied in Germany at a time when very few American students went abroad, but had also spent several months at Rothamsted, England, working under Lawes and Gilbert.

In 1856 the legislature of Maryland incorporated Maryland Agricultural College.

Under this law nearly 500 philanthropic and patriotic citizens of Maryland, with a few in other States and in the District of Columbia, subscribed the minimum amount of stock provided by the act and organized the institution. The stockholders met, elected the first board of trustees, and this body, after much deliberation, purchased for the college, from the late Charles B. Calvert, the estate known as Rossboro, containing 428 acres and situated in Prince George County, 8 miles from the city of Washington, and upon the Baltimore and Ohio Railroad. There the corner stone of the main college building was laid on August 24, 1858, and the institution was opened for students in September, 1859. The opening of the college was quite an imposing event. Bishop Pinkney was chaplain and Professor Henry, of the Smithsonian Institution, was the orator of the day.

Meanwhile, in 1856, Mr. Wilder, of Massachusetts, had succeeded in obtaining from the legislature of his State a charter of "The Trustees of the Massachusetts School of Agriculture," and from Congress a charter of the United States Agricultural Society, which had been formed in 1852. It is perhaps worth while to notice that the latter was opposed in the Senate by Jefferson Davis on the ground that "Congress had no power to create corporations."

THE FIRST MORRILL ACT.

The activity of the friends of agricultural education now began to extend itself beyond the limits of State legislation, and numerous petitions were presented to Congress asking for national aid for the establishment of agricultural colleges. The relation of this movement to that wider development of the American system of higher education due to the progress of the natural sciences and their application to the arts is thus briefly discussed by Professor Brewer, whose intimate personal acquaintance with many of the leaders of industrial, scientific, and educational progress in this period eminently qualifies him to speak of the causes which led to the passage of the Morrill act of 1862.

THE EVENTS LEADING UP TO THE MORRILL ACT.

The Morrill act of 1862 was the outcome of a long series of events which seem either to have been imperfectly understood by many writers or to have been deemed of an importance far below what they really had. The causes which led up to this grant of land for the purpose of aiding schools of science were numerous and not so simple as they seem now. Educational demands were doubtless the greater, but others, which need not be discussed in detail here, were important and, indeed, essential factors in promoting the passage of this act. Considered even as an educational movement, it was only a part of a wide movement, of which instruction in the sciences of immediate and special application in agriculture was but one phase.

It is true that there was a widespread and often-heard demand for agricultural

colleges during the twenty years preceding the passage of that act, but this was but one feature of a general educational movement.

The period between 1840 and 1860 was a peculiar one in the history of the world's intellectual activity and material progress. At its beginning some of the physical sciences, more particularly chemistry and geology, were scarcely 50 years old, but they had already revolutionized some of the arts and produced great changes in agriculture. All this had taken place within the lifetime of the older workers then in the field.

Popular works on science were widely read, and had prepared the public mind to cherish hopes, perhaps exaggerated, of the benefits to come by the applications of science, and had greatly stimulated intellectual activity in this new field of knowledge. Liebig's familiar Letters on Chemistry incited hopes for agriculture which will probably never be realized. Dick's works made the moon hoax[1] not only possible but such a great success as it never could have been before or since, and the discoveries actually taking place at that time awakened the most widespread desire to know more.

In a thousand and one ways, more in the other lines than in agriculture, discovery, invention, and the application of scientific laws to the arts and industries were playing a part in the development of the material resources of the civilized world and modifying the industries and occupations of men. There was then an absorbing interest in the growing steam transportation; railroads and ocean steamships then came into use and were made practicable; iron working, dyeing, and many other arts were being revolutionized by chemistry; commercial fertilizers were coming to be used; the electric telegraph, just invented, first came into use during this period; other events, some of them political, were profoundly affecting the current of human activity; prices, which had been falling from the decline of the production of silver in Mexico, began to rise with the discovery and production of gold in California. This was the beginning of an era in the rise of prices and of material prosperity unexampled in the history of civilization. The vine disease in the south of Europe, the potato disease in Ireland, the revolution in Germany, all occurring just as steamships began to carry immigrants, stimulated the immigration of working people as never before.

All these influences produced a deep and lasting effect on the theories and practice of education. The "old education," as it was called, did not supply the new wants. There was a loud and discordant demand for something else. The many agreed only in this, that less Latin and Greek (which had before been considered the corner stone and substance of a liberal education) be taught and in their place more science; or at least that, whatever place the old college curriculum might have in the future, new systems of education were required in this new development of civilization.

For example, great railroads were being surveyed and built; yet, aside from the national military school at West Point and personal instruction at places scattered here and there, there was but one engineering school in the United States previous to 1840.[2] So it is not wonderful that the matter of training in the sciences, pure and applied, was discussed when engineers were wanted and our factories, iron works, and other industries were asking for chemists. The old education was not sufficient for the new uses, but what the new education was to be and what were to be its schools no one seemed to know.

This discussion, along with that of elective studies instead of a rigid curriculum, went on in all the colleges and universities in the land. The University of Virginia

[1] [A fabulous account of telescopic information regarding the moon, published in the New York Sun, in which the writer went so far as to predict that we should soon be able to study the entomology of that satellite. Many persons believed this marvelous story.—Ed.]

[2] Renssalaer Polytechnic Institute at Troy, N. Y.

already had elective courses. All tried in some way to expand in the direction of the physical sciences.

The agitation for education in sciences began earlier, but the profoundest movement in the colleges took place between 1840 and 1850. Yale College then established its scientific and agricultural department, more agricultural than elsewhere because of the personal bent of Prof. John P. Norton, who was really the father of that department in Yale. Harvard started its scientific department at the same time—the Lawrence Scientific School—but the Lawrences, who gave the endowment of $40,000 to start it with, being prominently engaged in manufacturing, chemistry applied in the direction of the arts rather than in agriculture became there more prominent. While these old and reputable universities added scientific departments, others modified the curriculum in their literary courses to embrace more science. So profound was this movement that some very respectable institutions whose endowment did not permit of extensive expansion seriously considered the advisability of changing their plans and becoming essentially schools of science rather than of literature.

Prominent among those educators who agitated this question was Francis Wayland, then president of Brown University. Liberally educated, first at Union College, under the administration of the eminent Dr. Nott, then studying and graduating doctor of medicine, later a Baptist clergyman, he became eminent as a Baptist theologian, as a teacher, as a professor of moral science, but more so as a teacher and writer on educational matters. He was president of Brown University from 1827 to 1855, and between 1840 and 1855, the period I am more especially discussing, he took a more prominent part in the discussion of the new needs in education than any other college president of the country.

As early as 1842 he published a little book entitled Thought on the Present Collegiate System of the United States, in which he argues earnestly in favor of the introduction of new subjects into the college curriculum, much more attention to the sciences, and the adoption of a system of elective studies.

In A Sketch of the History and the Present Organization of Brown University, published by the executive board, Providence, 1861, we find that Wayland had come in as president in the college in the year 1826–27; that "his presidency was marked by greater changes and more numerous improvements than had been effected by either of his predecessors;" that a science hall and a museum of geology had been added in 1840; that the college was poor and not self-supporting, and that, "despairing of improvement so long as the existing system was perpetuated, Dr. Wayland in 1849 resigned his presidency;" that he, however, consented to reconsider his purpose, and the corporation falling in with him, "it was resolved to attempt to raise a fund for the purpose of realizing his theory of education; $125,000 was subscribed and what was called the new system was commenced." Its main features were a provision "for such new courses in science as the practical spirit of the age demanded, etc." The four-years' course was abolished, a three-years' course established, and several kinds of degrees conferred. This ran from 1850 to 1855; then Dr. Wayland, "having inaugurated his cherished plan," resigned, and Dr. Sears was put in his place. Dr. Sears already had fame as a theologian, and soon under him the four-years' course was reestablished, leading to the degree of A. B.

Going along with these changes in collegiate instruction there was much clamor for purely technical schools of special kinds. In no direction was this more marked than in agriculture. This became the field of work for enthusiasts of various grades and a bewildering number of schemes was proposed. A few private schools were started, but the loudest clamor was for State agricultural colleges. Many were planned, a few were chartered, and three or four actually opened before 1862.

These early agricultural colleges were certainly not at first a success. Some were total failures (as in New York), others hardly a success (as in Michigan and Pennsylvania). Why this was so was a matter of dispute. It is certain that they were poor in means, and to this cause many attributed the poverty of their results.

We ought here to say that previous to 1850 numerous private agricultural schools of a grade lower than colleges had been established in the United States and many were for a time reasonably successful. Such, for instance, was Dr. Gold's, in West Cornwall, Conn.

Not only were a few agricultural schools started, but also other schools in which the sciences were to be a leading feature.

Many prominent educators, however, came to think that their failure was because their aim was too narrow; that it was too early in this country for a narrow institution, supplying but a single want, to be successful; that scientific and practical institutions should be wider and with wider aims, inciting to higher culture and laying a more solid foundation; in short, that schools of science rather than trade schools were needed. Of colleges of the old-fashioned sort there were already enough and more than enough. The direction of their studies and system of instruction had been developed by centuries of experience which must not be rudely thrown aside. On the other hand, schools of science were too new and too few to show what was the best curriculum and what should be the details; consequently there was a wide difference of opinion as to how they might be best conducted. It was therefore but natural that practical success should come slowly and total failures be common.

Such was the condition of educational affairs when the Morrill act was discussed and passed. This wisely left the details to be developed in the respective schools. With a sagacity greater than that of most "educators" before and since, Mr. Morrill saw that schools grow rather than are made, and he therefore only indicated the general direction in which they should grow; that is, they were to be schools of science rather than schools of literature—institutions where the sciences and their application in agriculture and the arts were to be studied and cherished as the leading objects.

On December 14, 1857, Justin S. Morrill, then a member of the House of Representatives, and now a venerable Senator, from the State of Vermont, introduced a bill into the lower House authorizing the establishment of industrial colleges in every State, and granting for their maintenance 20,000 acres of the public land for each member of Congress. This bill was referred to the Committee on Public Lands, who brought in an adverse report April 15, 1858. Nevertheless, in the following session of Congress the bill passed both Houses, but was vetoed by President Buchanan.

In December, 1861, Mr. Morrill introduced in the House of Representatives his amended bill, which bestowed 30,000[1] acres of land for each member of Congress upon the several States for the establishment of colleges "to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life," and May 2, 1862, Benjamin Wade, of Ohio, introduced a similar bill in the Senate. On May 29 the bill was reported adversely in the House by the Committee on Public Lands, but was passed by the Senate June 10, and nine days later by the House. President Lincoln made the bill a law by affixing his signature July 2, 1862, the very day when McClellan's army began its retreat from the Peninsula after the bloody battle of Malvern Hill. Amid the national

[1] The amount of land actually allotted the several States was partly determined by the value of the land selected.

gloom which succeeded the failure of the Union's greatest army to take the capital of the Confederacy, few paid any attention to the gift of over 11,000,000 acres to promote the arts and industries of peace. It is a significant fact that in the amended bill it was provided that every institution receiving the benefits of the land grant should provide for the military training of its students.

As it was anticipated that the land grant would furnish a fund only sufficient for the partial support of such colleges as the several States ought to maintain for the benefit of the "industrial classes," the act provides that "no portion of said fund, nor the interest thereon, shall be applied, directly or indirectly, to the purchase, erection, preservation, or repair of any building or buildings." Ten per cent of the fund might, however, be expended "for the purchase of lands for sites or experimental farms." "The Federal Government," says Dr. Blackmar, in his History of Federal and State Aid to Higher Education, "intended the grant should form a nucleus in each of the several States around which buildings, libraries, laboratories, workshops, gymnasiums, military halls, and other educational appliances should be grouped by means of public munificence and State bounty. It was to prove a stimulus to the generosity of the people and the liberality of the States. To this test the people, through private gifts and municipal and State governments, have responded, with few exceptions, in a liberal way."

The shares of the several States under the land-grant act of 1862 ranged from 24,000 acres for Alabama to 990,000 acres for New York. The fund arising from the sale of the lands was not, however, proportionate in all cases to the number of acres received by the State. Many States sought to establish colleges very soon after the passage of the act, and in other States where the land grant was given to existing institutions the boards of management foolishly endeavored to convert the gift into cash at once. At the same time the homestead act, by enabling thousands of settlers to obtain land free of cost, and the extensive gifts of land to aid railroads, tended to depress the price of public lands offered for sale. The general result was that many States received small advantages from the land grant, the income from which in some cases was not sufficient to properly maintain even a single department of a college. In a few States, like New York and Michigan, where the number of acres received was large and the sale of the land was skillfully made, large funds were obtained and strong institutions were established. The total fund received from this land grant amounts to about $9,500,000, and about 1,200,000 acres still remain to be sold. The twenty-five years succeeding the passage of the act was necessarily a period of organization and of discussion regarding the character of the institutions which would fulfill the objects of the act and meet the needs of the industrial classes in the respective communities. The language of the act is broad and easily admits of widely diverse interpretation. It was not the intention to establish

agricultural colleges only, but rather institutions for "the liberal and practical education of the industrial classes in the several pursuits and professions in life." Whether a farmer's or mechanic's boy wished to become a doctor, machinist, or farmer, he was to have such instruction as he needed in the land-grant college. At the same time, in the agitation which preceded the introduction of the bill, in the speeches made in its favor, as well as in the act itself, special emphasis was laid upon agricultural education. The colleges to be founded under this act were in the minds of many to be to the profession of agriculture what West Point is to the profession of war. Unfortunately, the designation "agricultural colleges" was inserted in the title of the bill by the engrossing clerk and quickly passed into current use. In this way the real import of the act was obscured in the minds of the people, and the difficulties attending the proper administration of the fund were greatly increased.

It is also very important to remember in this connection that the definitions of the terms "liberal education," "practical education," "professions," as employed in the United States in 1862, were very different from those given to the same expressions to-day. A "liberal education" was then, in the popular mind, a medieval classical education; a "practical education" was one which fitted a man to earn his livelihood in any honest calling, and the "professions" were medicine, theology, and law. Reading, writing, and arithmetic were "practical" studies; Latin and Greek were "liberal" studies. Technical and scientific schools as we now know them were comparatively few and weak, and the period had not yet come when the ordinary education of the schools was not a passport to remunerative employment. It may be safely said that in 1862 an industrious boy of average common sense was sure of good wages if he could only get a common-school education. There is little wonder, then, that in carrying out the provisions of this act many of the States did little more than graft certain industrial features on new or old institutions which in general were like all the other institutions for higher education existing in the United States. Moreover, it could be fairly claimed that all institutions which made it easier for members of the industrial classes to obtain an education of any sort acted within the provisions of the Morrill act. But the land-grant colleges did far more than this. Almost all of them made more or less earnest efforts to secure agricultural students, and to provide at least a small amount of training in agricultural science. The farmers were not prepared to respond to these efforts. Many did not think there was or could be any science of agriculture worth learning. In the newer States the lands were so fertile and so cheap that farmers were highly prosperous under the most careless methods of agriculture. Moreover, when the immense volume of foreign immigration and the wonderful development of thousands of manufacturing and other industries in the United States since the civil war are considered, it

will not seem strange that the American farmer's boy of the period between 1862 and 1887 was not willing to stay on the farm, but sought the avenues leading to more rapid accumulation of wealth. It is easy to say now that the land-grant colleges ought to have resisted this tendency and held out larger inducements to pursue technical courses in agriculture; but when institutions deriving a large part of their support from the public purse were beset by the very class for which they were established with demands for a general education, and when there was no consensus among professional educators as to what should be included in agricultural courses, it could hardly be expected that the schools would refuse compliance with such requests. On the other hand, these colleges did much to inculcate a broader view of what constitutes a liberal education, and undertook much pioneer and experimental work in the development of technical courses suited to the needs of American farmers and mechanics. Even those which may seem to have done very little to directly benefit agriculture did in some cases the most valuable kind of work in preparing teachers and scientists who are now in the front ranks of those engaged in the work of technical instruction and in scientific and practical investigations in the agricultural schools and experiment stations throughout the country.

During this period clearer conceptions of what is desirable in courses of instruction in the sciences and arts, including agriculture, were being formed in the minds of educators and the public. Great changes and developments were taking place in all institutions of learning. The system of elective studies was steadily making its way and opening up wider opportunities for satisfying the demands of individuality in teacher and learner. Original research, which was all the while growing in importance and securing more brilliant and useful results in the Old World, began to assert its claims in the United States. Private benevolence was beginning to provide funds for the maintenance of such research in this country, and the people were gradually awaking to the necessity of promoting the interests of great industries by extending governmental aid to inquiries carried on in their behalf. Agriculture began to feel the influence of this movement. Experimental inquiries in field and laboratory were begun here and there, and very soon the regularly organized experiment station, after the German pattern, made its appearance in this country. Before proceeding to give a brief sketch of the history of the experiment stations let us consider for a moment the general status of the land-grant colleges just prior to the establishment of experiment stations under the act of Congress of March 2, 1887. The report of the United States Bureau of Education for 1886–87 contains the following general statements regarding these institutions:

The number of institutions in the United States sharing in the benefit of the land grant of 1862 is forty-eight.

In thirteen States the grant was made over to universities or colleges already exist-

ing, and has served to establish or augment the funds of courses, departments, or schools of applied science in the same. In the twenty-five remaining States the fund has served as the chief source of endowment for new institutions, or as the nucleus around which have collected additional funds, in several cases far exceeding the amount derived from the national grant. In six States the grant has been divided. In Georgia it has been applied to the endowment of six colleges of agriculture, affiliated to the State University; in Massachusetts separate colleges, one of agriculture, the other of the mechanic arts, have been the recipients; in Missouri a portion of the grant has been applied to the endowment of an "agricultural and mechanical college," and the rest to the endowment of a "school of mines and metallurgy," both under the auspices of the University of Missouri; in Mississippi, South Carolina, and Virginia the fund has been divided between institutions for white and colored students, respectively.

Certain of the schools have developed particularly in the direction of the mechanical arts; others are agricultural colleges, pure and simple; a few combine both departments, with large provision for theoretic instruction, while some differ in no essential particular from the ordinary classical college.

ORIGIN AND DEVELOPMENT OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

While the States had been active in establishing agencies for aiding the farmer in acquiring a better knowledge of his art and in improving its practice, the National Government had not neglected to provide a central bureau for doing its part in similar work.

The establishment of a national board of agriculture was one of the measures which President Washington strongly urged upon the attention of Congress. The propriety of giving national aid to agriculture was early considered by committees of both Houses of Congress, but the indifference of the farmers and constitutional objections prevented any legislative action. During the Administration of John Quincy Adams the consuls in various parts of the world were instructed to send to the Department of State rare seeds and plants for distribution, and about the same time a botanical garden was established at Washington. These measures proved to be the germs from which has grown the United States Department of Agriculture. When our Government was first organized, after the adoption of the Federal Constitution, the principal charge of the issuing of patents was given to the Department of State, and when seeds and plants were received from consuls they were distributed through the Patent Office. Thus it came to pass that when, on the 4th of July, 1836, the Patent Office was made a separate bureau, and Hon. Henry L. Ellsworth, of Connecticut, was appointed as Commissioner of Patents, he considered it within the proper scope of his office to help the farmers of the country by distributing seeds and plants. Mr. Ellsworth had been a practical farmer in Connecticut, and, having traveled far to the West as Indian Commissioner, had been greatly impressed by the fertility of the vast prairies and was deeply interested in projects for the opening of these lands to settlement. He also realized the importance of the invention of improved agricultural implements, which were then beginning to attract

public attention, and believed that great benefit might result from the establishment of a regular system for the selection and distribution of grains and seeds of the choicest varieties for agricultural purposes. So earnest was he in this matter that, without legal authorization and outside of office hours, he secured free gifts of seeds and plants, which he afterwards distributed to farmers in various sections of the country, with the help of friendly members of Congress, who lent their franks for this purpose. Beginning with his first annual report, dated January 1, 1838, he strongly urged an appropriation to continue and enlarge this work, and in the closing hours of the Twenty-fifth Congress secured the passage of an act (March 3, 1839) appropriating $1,000, "to be taken from the Patent Office fund, for the purpose of collecting and distributing seeds, prosecuting agricultural investigations, and procuring agricultural statistics." From that time up to 1854 seeds were distributed and agricultural statistics were compiled with the aid of small appropriations from the Patent Office fund, except in 1840, 1841, and 1846, when Congress failed to make any appropriation for this purpose. In 1854 the policy of appropriating money from the Patent Office fund was abandoned, and in the following year the whole amount ($39,000) drawn from that fund in the interest of agriculture was reimbursed, and thereafter the appropriations for agriculture were drawn directly from the Treasury. The same year the annual appropriation for agriculture was increased to $35,000, and has never since been less than that sum. A special agent was now employed "to investigate and report upon the habits of insects injurious and beneficial to vegetation, especially those infesting the cotton plant." In 1855 an arrangement was made with the Smithsonian Institution for procuring and publishing meteorological statistics. A chemist and botanist were also employed, and a propagating garden was begun. The first annual report of Commissioner David P. Holloway, of Indiana, is worthy of notice as the last and most complete agricultural manual issued by the Patent Office, and as containing a bold and able plea for the creation "of a Department of the Productive Arts, to care for all the industrial interests of the country, but especially for agriculture." Congress adopted a portion of the Commissioner's plan, and passed a bill establishing a Department of Agriculture. This act became a law by the approval of President Lincoln on the 15th of May, 1862, and on the 1st of July of the same year the new Department was formally organized in the rooms of the Patent Office previously occupied by the agricultural division of that Office. Though by the terms of the act an independent department of the Government was established, its chief officer was styled Commissioner of Agriculture and was not a member of the President's Cabinet. The duties of the Department as defined in this act are, "To acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word, and

to procure, propagate, and distribute among the people new and valuable seeds and plants." Hon. Isaac Newton, of Pennsylvania, who had been, since early in 1861, the superintendent of the agricultural division of the Patent Office, was appointed the first Commissioner of Agriculture. Mr. Newton had been a practical and progressive farmer, was one of the first and most active members of the State Agricultural Society of Pennsylvania, and had for years urged upon Congress the importance of establishing such a department as that over which he was now called to preside.

Upon assuming the duties of his office he at once proceeded to organize the Department in accordance with the liberal spirit of the act creating it. * * * The clerical force of the former agricultural division was increased; a chemist was engaged and a laboratory established; a skilled horticulturist was placed in charge of the propagating or experimental garden; greater activity in the collection and dissemination of current agricultural facts was inaugurated, and a larger quantity of seeds and cuttings was distributed. * * * A statistical branch was organized early in 1863, and to it was committed the collection and analysis of all statistics. Lewis Bollman, of Indiana, was appointed statistician. To ascertain, at the earliest practical period, the condition of the crops, their yield, the prices obtained for them, and other facts connected with current agricultural operations, the Commissioner issued during 1863 periodical circulars to farmers in every county of the loyal States. The results thus obtained were given to the public through the medium of monthly reports, which have been continued to the present time, with such modifications of their original features as time and experience have seemed to render necessary. The first monthly report was issued July 10, 1863. The publication in the monthly reports of monthly and bimonthly meteorological tables furnished by the Smithsonian Institution was commenced at the same time. These tables were reproduced in the ensuing annual report. Up to 1872 the same arrangement concerning these tables continued in force, when their further publication was suspended.

The employment of a skillful gardener was one of the most auspicious incidents of the first year of Mr. Newton's administration. He was fortunate in procuring the services of William Saunders, who has ever since given to the important duties assigned to him an intelligent and conscientious devotion.

In the second year of Mr. Newton's administration (1863) Townend Glover was appointed entomologist. In 1864 the Government reservation in the city of Washington lying between the Smithsonian Institution and the Washington Monument, and embracing 35 acres, was assigned to the Department of Agriculture. For several years this land was chiefly used as an experimental farm. The main building now occupied by the Department was erected on this farm, being completed in 1868. At that time the grounds were converted into a landscape garden, comprising a collection of hardy trees and shrubs arranged in their natural orders.

As the progress of agricultural science demanded new divisions of the work and the means at the disposal of the Department enabled it to widen the range of its efforts, one scientific branch after another was added. In 1884 the Bureau of Animal Industry was established to investigate and report upon the diseases of domestic animals, especially pleuropneumonia, and to devise measures for improving the animal industries of the country. The Bureau has since been charged with

the inspection of import and export animals and of live stock and their products slaughtered for food consumption. On the 11th of February, 1889, President Cleveland approved the act of Congress to make the Department of Agriculture an Executive Department, and nominated Norman J. Colman, of Missouri, the last Commissioner of Agriculture, to be the first Secretary of Agriculture. With the change of Administration, on March 4 of the same year, Jeremiah M. Rusk, of Wisconsin, was appointed Secretary of Agriculture by President Harrison, and Edwin Willits, president of the Michigan Agricultural College and director of the experiment station connected with that institution, was appointed Assistant Secretary. During their administration the Department was further developed by the addition of the Weather Bureau, which had been a branch of the Signal Service of the Army, and was, under act of Congress, transferred, on July 1, 1891, to this Department.

As at present reorganized by Secretaries Rusk and Morton, the Department of Agriculture has been divided into two grand divisions. One division embraces all branches of the Department which are more particularly charged with administrative and executive functions, and which, for that reason, are conducted under the personal supervision of the Secretary. The other division includes those branches which are chiefly engaged in investigations in agricultural science, and which are in immediate charge of the Assistant Secretary. Under the present organization, the Secretary supervises the Weather Bureau, Bureau of Animal Industry, Divisions of Statistics, Forestry, Records and Editing, Accounts, Seeds, Garden and Grounds, Road Inquiry, and the Library. The Assistant Secretary supervises the Office of Experiment Stations, the Divisions of Chemistry, Entomology, Ornithology and Mammalogy, Botany, Pomology, Vegetable Pathology, Microscopy, Agricultural Soils, Irrigation, Fiber Investigations, and the Museum. The duties of the several branches of the Department are briefly described in the Appendix. While the administrative and executive functions of the Department have been greatly enlarged by recent legislation, the scientific and practical investigations have been pursued with increasing activity, and the results of its work are more widely distributed and more highly appreciated than ever before. The growth of the Department is strikingly illustrated in the rapid increase in the amount of information which it has disseminated during the past five years. In 1889 the Department issued 78 publications, in editions aggregating 526,537 copies. During the fiscal year ending June 30, 1894, 205 publications passed through the Division of Records and Editing, all but 6 of which directly issued from this Department. The editions of these publications aggregated 3,169,310 copies.

That this Department has been a mighty factor in the education of the farmers of this country probably no one will deny. For our purpose,

however, it is only necessary to observe here that the Department has developed very strongly in the direction of original research in behalf of agriculture. In considering the history of the experiment stations in the States it should never be forgotten that the Department has for many years had within itself what is practically a great experiment station, and that it is a very important feature in the great system of experimental research in agriculture which has been established in this country, very largely with the aid of funds drawn from the National Treasury.

THE AGRICULTURAL EXPERIMENT STATIONS.

We have already seen how the idea that experiments with a view to improving agricultural practice should be carried on, along with instruction in agriculture, had been more or less prominent in the minds of leaders in agricultural progress in this country for many years. At first it was thought that all that was necessary for this purpose was to establish experimental farms on which new varieties of plants or new processes of culture of crops could be tested, or practical experiments in the feeding or breeding of animals could be conducted. Before the middle of this century, however, the investigations of such chemists as Liebig, in Germany, and Boussingault, in France, had shown that science could be made useful to agriculture as well as to other arts. Indeed, Liebig's theory of fertilizers aroused extravagant expectations in the popular mind, and it was hoped that chemical analysis of soil and plant would be an infallible guide to show what manuring of the crop would produce the most abundant harvests. In the period between 1840 and 1850 Liebig's Familiar Letters on Chemistry were printed in cheap form and widely read in this country. In 1843 Lawes and Gilbert began, at Rothamsted, England, that remarkable series of field and laboratory experiments which has been continued under the same management for half a century.

"The beginning of the experiment station proper, the organization of scientific research with the aid of Government 'as a necessary and permanent branch of agricultural business,'" came in 1851, when a "company of Saxon farmers joined themselves together in the little German village of Moeckern, near the city and under the influence of the University of Leipsic, called a chemist to their aid, and with later help from Government, organized the first agricultural experiment station." As soon as agricultural colleges were established in this country experimental investigations in field and laboratory were undertaken, but for a number of years these were carried on with small means and for the most part by the voluntary labor of professors outside of their regular duties as instructors.

The act to establish and endow an agricultural college passed by the legislature of Maryland in 1856 contains the following section:

SEC. 6. It shall be the duty of the said board of trustees to order and direct to be made and instituted on said model farm, annually, a series of experiments upon the

cultivation of cereal and other plants adapted to the latitude and climate of the State of Maryland, and cause to be carefully noticed upon the records of said institution the character of said experiments, the kind of soil upon which they were undertaken, the system of cultivation adopted, the state of the atmosphere, and all other particulars which may be necessary to a fair and complete understanding of the result of said experiments.

The records of the college show that in 1858, immediately after the college was located, and before building began, field experiments with corn, oats, and potatoes, "to test the relative value of the different manures offered for sale in the cities of Baltimore and Washington," were commenced on the college farm. This work continued for two or three years, but was interrupted by the financial distress which soon affected the whole country and by the disturbed political condition of the State and nation.

In 1870 the president and fellows of Harvard College began to organize the school of agriculture and horticulture which had been provided for in the will of Mr. Benjamin Bussey, of Roxbury, Mass. This interesting document was signed July 30, 1835, and was proved soon after the death of the testator, in 1842. It bequeathed half of the income of about $300,000 and 200 acres of land in Roxbury to the president and fellows of Harvard College, on condition that they establish on the farm "a course of instruction in practical agriculture, in useful and ornamental gardening, in botany, and in such other branches of natural science as may tend to promote a knowledge of practical agriculture and the various arts subservient thereto." Owing to other provisions of the will, it was not deemed advisable to begin the formation of the Bussey Institution earlier than 1870. In the same year the trustees of the Massachusetts Society for Promoting Agriculture granted to the corporation of Harvard College a considerable sum "for the support of a laboratory and for experiments in agricultural chemistry, to be conducted on the Bussey estate." The laboratory of the new institution was not ready for occupation until the last week in 1871. As soon as it was completed, however, agricultural researches were begun by F. H. Storer, the professor of agricultural chemistry, and his assistants. The first report of this work was presented to a committee of the trustees of the Massachusetts Society for Promoting Agriculture, December 3, 1871. The experiments consisted of field tests of fertilizers upon the farm of the institution, and chemical analyses of commercial fertilizers. Other interesting and valuable work was done in the next few years, but the great fire in Boston in 1872 and the commercial crisis of 1873 combined to cripple the institution financially, and it has since been able to make comparatively few original investigations.

When the College of Agriculture of the University of California was organized it was understood that a part of its work would consist of experimental inquiries. In 1870 Prof. E. S. Carr, in an address at the State Fair, made the following specific allusion: "The University proposes to furnish the facilities for all needful experiments; to be the

station where tests can be made of whatever claims attention." A later report contains the following statements regarding the development of experimental inquiries in agriculture at the University:

Ex-President Gilman, in his report dated December 1, 1873, alludes to progress in this work, as follows:

"The University domain is being developed with a view to illustrate the capability of the State for special cultures, whether of forests, fruits, or field crops, and the most economical methods of production. It will be the station where new plants and processes will be tested and the results made known to the public. * * * A fine estate has been provided, well adapted to the establishment of an experiment station in agriculture, a botanic garden, an arboretum, etc."

As is usual in the history of new undertakings, progress at first was slow and hesitating. The report for the years 1873–1875, by R. E. C. Stearns, at that time secretary of the board of regents, shows that 40 acres were prepared for planting with a view to agricultural experiments in 1874, and that during the winter following there were planted 584 named varieties of tree fruits, 73 of grapevines, and 95 of various small fruits. * * *

In 1874 buildings were erected on the grounds set apart for agricultural experiments, viz: A barn 36 by 44 feet; a tool house 64 by 12 feet; two propagating houses, one 64 by 15 feet, the other 30 by 24 feet; a house for hatching fish eggs; and in addition to these larger structures a complement of sheds and outbuildings, hot beds, and cold frames were provided. Propagation of shrubs and trees from seed obtained abroad, and especially from other arid regions of the world, was first undertaken.

In 1874 E. W. Hilgard was chosen professor of agriculture. [Prof. Hilgard had previously been engaged for a number of years in conducting an agricultural and geological survey in Mississippi, in connection with which chemical examinations of soils, field experiments, and other agricultural investigations had been incidentally carried on in accordance with a plan inaugurated as early as 1857 and afterwards made the basis for the highly successful work of the California Experiment Station under his direction.] In the winter of 1875–76 the first field experiments were undertaken to determine the effects of deep culture and of the application of various fertilizers.

In 1875 the laboratory branch of the experiment station work was inaugurated, the regents making provision for the expenses thereof for the first two years; and at the end of this time the legislature opened the way for the continuation and extension of the work by liberal special appropriations from year to year.

After the fund which had been established by the sale of the land scrip donated to Connecticut under the act of Congress of July 2, 1862, had been given to the Sheffield Scientific School of Yale College in 1863, a professor of agriculture was added to the working force of that institution. Samuel W. Johnson, M. A., the successor of Professor Norton as professor of theoretical and agricultural chemistry, and William H. Brewer, Ph. D., the professor of agriculture, have for many years taken an active interest in all work for the promotion of agricultural science in Connecticut and elsewhere in the United States. Under their direction experimental work for the benefit of agriculture was carried on to a limited extent at New Haven more than twenty-five years ago, and it is doubtless safe to say that "through the influence of the professors and pupils trained in this school, more than to any other single cause, is due the recognition of the importance of the

establishment of agricultural experiment stations, first in Connecticut and subsequently throughout the whole country." Prof. W. O. Atwater, the first director of the first regularly organized experiment station in this country, received a part of his training in this school.

The reports of the successful and beneficial work done in the European experiment stations excited more and more attention on this side of the Atlantic, and the more advanced leaders in agricultural progress in this country began to ask for the establishment of similar institutions in the United States. In 1872, at a convention of representatives of agricultural colleges held in Washington in response to a call issued by the United States Commissioner of Agriculture, the question of the establishment of experiment stations was discussed, and the report of a committee in favor of such institutions was adopted by the convention. On the 17th of December, 1873, at the winter meeting of the State board of agriculture, at Meriden, Conn., Professor Johnson, of the Sheffield Scientific School, and Professor Atwater, of Wesleyan University, urged the establishment of an agricultural experiment station in that State after the European pattern. A committee was appointed to consider the expediency of such a movement, and reported two days later that it was their "unanimous opinion that the State of Connecticut ought to have an experiment station as good as can be found anywhere, and that the legislature of the State ought to furnish the means for its establishment." A permanent committee was then appointed by the board to bring this matter to the attention of the public and the legislature. This committee held meetings in different parts of the State, and the following winter secured the introduction of a bill for an experiment station, which, however, was laid over until the next session of the legislature. Another year of agitation of the matter ensued. The project had many warm and enthusiastic friends, but, as might have been expected, the great mass of the farmers took little interest in the enterprise. When it had become apparent that it could not succeed, Mr. Orange Judd, the editor and proprietor of the American Agriculturist, offered on his own part $1,000 to begin the undertaking, and on the part of the trustees of Wesleyan University, at Middletown, the free use of the chemical laboratory in the Orange Judd Hall of Natural Science.

These offers were made on condition that the legislature should appropriate $2,800 per annum for two years for the work of the station It was thought that if by these means the work of agricultural experimentation could actually be begun, the usefulness of the enterprise would be so clearly demonstrated that it would speedily receive more generous and permanent support. An act making the appropriation thus proposed was unanimously passed, and approved July 2, 1875. Early in October of the same year a chemist was on the ground, and as soon as practicable two assistants were secured. Professor Atwater was made director, and thus the first agricultural experiment station

in America was an accomplished fact. Notwithstanding the severe financial depression of 1877, which caused serious reduction in old appropriations and utter refusal of new ones by the legislature of that year, a bill prepared by the director of the station and making a permanent annual appropriation of $5,000 "to promote agriculture by scientific investigation and experiment" was passed unanimously. At the end of the two years provided for in the original bill the station was reorganized under the direct control of the State and permanently located in New Haven where it has since been in successful operation, until 1882 in the chemical laboratory of the Sheffield Scientific School, and thereafter in buildings and on grounds provided by the State in the suburbs of the city.

The success which attended this first attempt to establish an organized experiment station in the United States was sufficient to attract the attention of advanced agriculturists throughout the country, and the example set by Connecticut was soon followed in other States. March 12, 1877, the State of North Carolina established an agricultural experiment and fertilizer control station at Chapel Hill in connection with the State University in accordance with an act of the legislature creating a Department of Agriculture, Immigration, and Statistics. The Cornell University experiment station was organized in February, 1879, by the faculty of agriculture of the university, as a voluntary organization. From that time until the passage of the act of Congress of March 2, 1887, the work was carried on by the different professors in such time as could be spared from other studies. For a part of that time the trustees of the university appropriated money from the university funds to pay for the services of an analyst and for the purchase of supplies. All the other work was done without compensation.

The New Jersey State station at New Brunswick, N. J., was established March 18, 1880, by an act of the State legislature and connected with the scientific school of Rutgers College.

The movement grew in favor with the people with each succeeding year, and in 1886 the Committee on Agriculture in reporting the Hatch bill to the House was able to make the following statements:

Since 1881 the legislatures of several States have either recognized or reorganized the departments of agriculture in the land-grant colleges as "experiment stations," thus following substantially the course adopted by New Jersey. Such stations have been established in Maine, Massachusetts, Ohio, Tennessee, and Wisconsin. In three other States (possibly more), without legislative action, the college authorities have organized their agricultural work as experiment stations. This has been done in California, Missouri, and New York. But in addition to the twelve experiment stations specifically designated by that name a very large number of the colleges established under the act of 1862 are doing important work of a precisely similar kind. Many of them began such work immediately upon their establishment, and have since maintained it continuously; others have entered upon it more recently. The colleges in Colorado, Indiana, Kansas, Michigan, and Pennsylvania are carrying on what is strictly experiment-station work as a part of their ordinary duty.

The convention of delegates of agricultural colleges which met at Washington in 1883 discussed and indorsed the project for the establishment of stations in connection with the colleges by appropriations from the national Treasury, in accordance with the terms of a bill already introduced in the House of Representatives by C. C. Carpenter, of Iowa. Congress, however, was not yet quite ready to undertake so large a scientific enterprise in this direction, and the bill was not put upon its passage. Meanwhile the number of stations was steadily increasing, and the interest of practical farmers, as well as men of science, was more and more excited by the reports of the results of the experiments which the stations had completed. On July 8, 1885, a convention of agricultural colleges and experiment stations met at the Department of Agriculture at Washington, in response to a call issued by the Commissioner of Agriculture. Almost the first thing which this convention did was to pass a resolution "that the condition and progress of American agriculture require national aid for investigation and experimentation in the several States and Territories; and that therefore this convention approves the principle and general provisions of what is known as the Cullen bill of the last Congress, and urges upon the next Congress the passage of this or a similar act." (The Cullen bill was in its general provisions similar to the bill afterwards passed by Congress and now popularly known as the Hatch act.) So earnest was the convention in this matter that it appointed a committee on legislation, which was very efficient in securing the passage of the amended bill.

In a later session the convention passed resolutions urging the creation of a branch of the Department of Agriculture at Washington which should be a special medium of intercommunication and exchange between the colleges and stations, and which should publish a periodical bulletin of agricultural progress, containing in a popular form the latest results in the progress of agricultural education, investigation, and experimentation in this and in all other countries. Provision was also made for a permanent organization by the appointment of a committee to cooperate with the United States Commissioner of Agriculture in determining the time of meeting and the business of the next convention, and in forming a plan for a permanent organization.

At the next session of Congress the experiment-station enterprise was again called to the attention of the House of Representatives by the bill which was introduced by William H. Hatch, of Missouri, and referred to the Committee on Agriculture. This committee made a favorable report March 3, 1886, and nearly a year later the bill was passed by Congress, and was approved by President Cleveland March 2, 1887.

The Hatch act provides that $15,000 a year shall be given out of the funds proceeding from the sale of public lands to each State and Territory for the establishment of an agricultural experiment station,

which must be a department of the land-grant college, except in the case of those States which had established experiment stations as separate institutions prior to the passage of the act.

The duties of the stations are thus defined:

SEC. 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or Territories.

In order that the funds from the national Treasury might be for the most part devoted to agricultural investigations, only \$3,000 of the first year's appropriation for each station was to be expended for buildings, and thereafter only \$750 a year could be so expended.

That the farmers of the country may receive prompt information regarding the work of the stations, it is provided that in addition to "full and detailed" annual reports of their operations and expenditures, "bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the States or Territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same and as far as the means of the station will permit." The franking privilege is also given for the station publications. Financial and other reports of the stations are to be sent to the Secretaries of Agriculture and the Treasury, but no provision is made for auditing the accounts by officers of the United States or for any supervision of their work by the Federal authorities. It is, however, made the duty of the Secretary of Agriculture "to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate, from time to time, such lines of inquiry as to him shall seem most important; and, in general, to furnish such advice and assistance as will best promote the purpose of this act." In the appropriation act for the Department of Agriculture for the present fiscal year it is provided that "the Secretary of Agriculture shall prescribe the form of the annual financial statement required by section 3 of the said act of March 2, 1887; shall ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of the said act, and shall make report thereon to Congress."

ESTABLISHMENT OF THE OFFICE OF EXPERIMENT STATIONS.

On the 18th of October, 1887, the second convention of agricultural colleges and experiment stations convened at Washington. A permanent organization was effected, and the association was named "The Association of American Agricultural Colleges and Experiment Stations." George W. Atherton, LL. D., president of the Pennsylvania State College, was elected president of the association. This convention was deeply interested in securing the coordination of the work of the several stations, and indorsed the action of previous conventions in urging the establishment of a central bureau. As the result of the efforts of this association, an appropriation to enable the Commissioner of Agriculture to carry out the provisions of section 3 of the act establishing the stations was included in the annual appropriation bill for the Department of Agriculture for the fiscal year ending June 30, 1889, and the Commissioner of Agriculture instituted in October, 1888, an Office of Experiment Stations as a special branch of the Department of Agriculture.

Prof. W. O. Atwater was appointed director of the office, and continued in this position until July 1, 1891, when he was succeeded by Prof. A. W. Harris, who had been assistant director, and who resigned in 1893 to become president of Maine State College.

THE SECOND MORRILL ACT.

As the organization of the land-grant colleges proceeded and the system of technical education in agriculture and other industries was elaborated it seemed to Mr. Morrill and other friends of industrial education that the income derived from the land-grant funds, even when supplemented by liberal contributions from the States and other sources, was inadequate to the demands of modern collegiate instruction in such lines. Mr. Morrill, therefore began to formulate plans to secure additional aid for these institutions from the national Treasury. Meanwhile the subject of Federal aid to the common schools throughout the Union was agitated, mainly through the debate which went on for years in Congress and in the country over the propositions of Mr. Blair, of New Hampshire, to extend such aid on the basis of the relative illiteracy in the several States. When it became evident that a general measure of this kind would not receive the sanction of Congress, Mr. Morrill introduced a bill to provide for the further endowment of the land-grant colleges, and this was passed and received the approval of President Harrison August 30, 1890. The second Morrill act provides that there shall be annually appropriated to each State and Territory, out of the funds arising from the sale of public lands, for the more complete endowment and maintenance of colleges for the benefit of agriculture and the mechanic arts established under the act of 1862, the sum of $15,000 for the year ending June 30, 1890, and an annual

increase of the amount of such appropriation for ten years thereafter by an additional sum of $1,000 over the preceding year, and that then the amount shall continue at $25,000. This money can be applied "only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction." Provision is made for separate institutions for white and colored students in such States as may desire to make such an arrangement. The Secretary of the Interior is charged with the administration of the law, and is given authority to withhold the appropriation to any State or Territory for cause, subject to an appeal to Congress.

PRESENT STATUS OF AGRICULTURAL EDUCATION AND INVESTIGATION IN THE UNITED STATES.

Having briefly described the origin of different agencies for the education of the farmer and the improvement of his art, it remains to outline the system for agricultural education and research as it now exists in this country. In doing this it will be necessary to exclude those general educational agencies, such as newspapers, State and local societies, farmers' institutes, and the State departments of agriculture, which to a greater extent than ever before are disseminating valuable information and stimulating or conducting inquiries for the benefit of agriculture. No further reference seems to be needed here to the United States Department of Agriculture except what is said below regarding the Office of Experiment Stations in its relations to the agricultural experiment stations in the different States.

COLLEGES HAVING COURSES IN AGRICULTURE.

Under the provisions of the acts of Congress of July 2, 1862, and August 30, 1890, 65 institutions are in operation in the several States and Territories. Of these, about 60 institutions maintain courses in agriculture. In 14 States separate institutions are maintained for white and colored students. The organization of these institutions is so varied that an exact classification of them is impracticable. In a general way, however, they may be classified as follows: (1) Universities having colleges or departments of agriculture; (2) colleges of agriculture and mechanic arts; (3) colleges of agriculture; and (4) secondary schools of agriculture. In these institutions the college course in agriculture leading to a degree covers four or in some cases three years, and in a number of institutions is supplemented by post-graduate courses. Shorter courses of one or two years or of a few months are also provided in many institutions. Special courses in dairying and in other agricultural industries have been recently established at a few of the colleges.

Some institutions have preparatory classes in which instruction in agricultural subjects is given. An attempt is being made to establish courses of home readings for farmers under the direction of the colleges, the Pennsylvania State College being the first institution to introduce this feature. In a number of States courses of lectures in farmers' institutes held in different localities are given by members of college faculties during the winter months.

The total number of officers in the faculties of the colleges having courses in agriculture in 1894 is 1,643, and the total number of students is 21,195, of whom 3,847 are in the courses in agriculture. The graduates from the courses in agriculture in 1894 numbered 229, and the total number of graduates in those courses since the establishment of the colleges is 3,003.

The total revenue for the fiscal year ending June 30, 1894, was $4,458,014, from the following sources: United States—Income of land grant of 1862, $618,273; appropriation under act of Congress of 1890, $943,837; total, $1,562,110; State, $1,337,928; local communities and individuals, $195,914; fees, $357,759; farm produce, $114,167; miscellaneous, $687,067.

The value of additions to equipment in 1894 is estimated as follows: Buildings and land, $998,632; libraries, $72,874; apparatus, $229,499; farm implements, $26,346; live stock, $10,857; miscellaneous, $77,284; total, $1,415,495.

Owing to the complicated organization of many of these institutions and the fact that the students in agricultural courses are in many subjects in classes with students in other courses, and that much of the equipment is used in common by the students in all the courses, it is impracticable to show by statistics with exactness the means and facilities for strictly agricultural education.

The following general statements regarding these institutions are from the report of the director of the Office of Experiment Stations for 1893:

> The reports received from the colleges during the past two years indicate that while the facilities for instruction in agricultural courses have been increased as the result of the act of Congress of 1890, the number of students in the regular college courses in agriculture still continues to be relatively small in many institutions. On the other hand, the short courses are increasingly popular, and wherever special courses, as in dairying, have been established they have been well attended. The success of the schools of agriculture having a curriculum of lower grade than that of the college, in Minnesota, Rhode Island, and Connecticut, is evidence that there is a demand for institutions which will receive students directly from the common schools and give them training in agricultural subjects along with those ordinarily taught in high schools. Experience in agricultural education in this country during the past thirty years shows that colleges of agriculture are mainly for those who have the means and the leisure to gain that liberal education which will fit them to be investigators, teachers, journalists, and managers of large agricultural enterprises. In a word, the colleges are principally useful in training the leaders in agricultural progress. This is a high duty, and its successful performance should entitle an institution to the gratitude and support of the people. But there is need

that the masses of our agricultural population should have more ample opportunities for education in agricultural lines.

The experiment stations, through their bulletins and reports, are doing much to educate the adult farmer. The colleges also are doing more each year in what may be called university-extension work through farmers' institutes. As the demand for instruction in agriculture increases the colleges will undoubtedly shape their courses to meet the needs of the farmers as far as this is practicable. We shall then have experiment stations, college courses in agriculture, schools of agriculture, special schools in dairying, animal production, etc., farmers' institutes, and home readings as the complete system of education for the farmer, carried on under the auspices of the university or college.

AGRICULTURAL EXPERIMENT STATIONS.

Agricultural experiment stations are now in operation under the act of Congress of March 2, 1887, in all the States and Territories. Alaska is the only section of the United States which has no experiment station. In each of the States of Alabama, Connecticut, Massachusetts, New Jersey, and New York a separate station is maintained wholly or in part by State funds, and in Louisiana a station for sugar experiments is maintained mainly by funds contributed by sugar planters. In several States substations have been established. Excluding the branch stations, the total number of stations in the United States is 55. Of these 51 receive the appropriation provided for in the act of Congress above mentioned. The total income of the stations during 1894 was $996,157, of which $719,830 was received from the National Government, the remainder coming from State governments, private individuals, fees for analyses of fertilizers, sales of farm products, and other sources. In addition to this, the Office of Experiment Stations has an appropriation of $25,000 for the current fiscal year. The value of additions to equipment in 1894 is estimated as follows: Buildings, $43,822; libraries, $9,286; apparatus, $22,711; farm implements, $15,824; live stock, $13,373; miscellaneous, $31,382; total, $136,901.

The stations employ 577 persons in the work of administration and inquiry. The number of officers engaged in the different lines of work is as follows: Directors, 67; secretaries and treasurers, 26; librarians, 8; clerks, 27; in charge of substations, 40; agriculturists, 55; biologists, 11; botanists, 36; chemists, 124; entomologists, 43; geologists, 5; horticulturists, 61; irrigation engineers, 7; meteorologists, 15; mycologists and bacteriologists, 7; physicists, 3; veterinarians, 24; dairymen, 11; farm foremen, 25. There are also 28 persons classified under the head of "miscellaneous," including superintendents of gardens, grounds, and buildings, apiarists, herdsmen, etc.

In 1894, 54 annual reports and 401 bulletins were issued. Besides regular reports and bulletins, a number of the stations issue press bulletins, which are widely reproduced in agricultural and county papers. The station bulletins are now regularly distributed to half a million

persons, who are either farmers or closely identified with the agricultural industry. Moreover, accounts of station work are given and discussed in thousands of newspapers. The New York Cornell Station alone estimated some time ago that each one of its publications directly or indirectly reached more than half a million readers. Besides this, a very large correspondence with farmers is carried on, hundreds of public addresses are annually made by station officers before farmers' meetings, and the results of station work are taught to thousands of students in agricultural colleges.

The experiment stations are conducting a wide range of scientific research in the laboratory and plant house and an equally large amount of practical experimenting in the field, the orchard, the stable, and the dairy. Thirty stations are studying problems relating to meteorology and climatic conditions. Forty-three stations are at work upon the soil, investigating its geology, physics, or chemistry, or conducting soil tests with fertilizers or in other ways. Twenty stations are studying questions relating to drainage or irrigation. Thirty-nine stations are making analyses of commercial and homemade fertilizers, or are conducting field experiments with fertilizers. At least fifteen stations either exercise a fertilizer control in their respective States or make analyses on which the control is based. Forty-eight stations are studying the more important crops, either with regard to their composition, nutritive value, methods of manuring and cultivation, and the best varieties adapted to individual localities, or with reference to systems of rotation. Thirty-five stations are investigating the composition of feeding stuffs, and in some instances making digestion experiments. Twenty-five stations are dealing with questions relating to silos and silage. Thirty-seven stations are conducting feeding experiments for milk, beef, mutton, or pork, or are studying different methods of feeding. Thirty-two stations are investigating subjects relating to dairying, including the chemistry and bacteria of milk, creaming, butter making, or the construction and management of creameries. Forty-five stations are studying methods of analysis and doing other chemical work. Botanical studies occupy more or less of the attention of twenty-seven stations; these include investigations in systematic and physiological botany, with especial reference to the diseases of plants, testing of seeds with reference to their vitality and purity, classification of weeds and methods for their eradication. Forty-three stations work to a greater or less extent in horticulture, testing varieties of vegetables and large and small fruits, and making studies in varietal improvement and synonymy. Several stations have begun operations in forestry. Thirty-one stations investigate injurious insects with a view to their restriction or destruction. Sixteen stations study and treat animal diseases or perform such operations as dehorning of animals. At least seven stations are engaged in bee culture, and three in experiments with poultry.

In general the work of the agricultural experiment stations, as organized in this country, may be classified as follows: (1) They act as bureaus of information on many questions of practical interest to the farmers of their several localities; (2) they seek by practical tests to devise better methods of agriculture and to introduce new crops and live stock, or to establish new agricultural industries; (3) they aid the farmer in his contest with insects and with diseases of his crops and live stock; (4) they help to defend the farmer against fraud in the sale of fertilizers, seeds, and feeding stuffs; (5) they investigate the operations of nature in the air, water, soil, plants, and animals in order to find out the principles which can be applied to the betterment of the processes and products of agriculture.

OFFICE OF EXPERIMENT STATIONS.

As already stated above, the Office of Experiment Stations was established in the United States Department of Agriculture to render such advice and assistance to the stations as would best promote the objects for which they were established. Its main business has been the examination of the work of agricultural experiment stations in this and other countries and the collation and publication of data regarding experimental inquiries in agriculture for the information of station workers, farmers, and others interested in the progress of the science and art of agriculture. There are now some 320 experiment stations in operation in the different countries of the world. Besides the publications which these stations issue, very many reports of agricultural inquiries at these and other institutions are published in current periodicals. As far as practicable this office seeks to traverse this large mass of literature and to cull from it such information as will enable our station workers to keep posted regarding the progress of agricultural science, and will promptly bring to our farmers the practical outcome of these investigations in the different countries.

Up to January 1, 1895, the office had issued 135 documents, including 5 volumes of the Experiment Station Record, 20 bulletins, and 9 Farmers' Bulletins.

The Experiment Station Record is issued in monthly parts, and contains abstracts of current publications of all the American stations, of the several divisions of the United States Department of Agriculture, and of reports of foreign investigations in agricultural science. General information is also given regarding the stations and kindred institutions in this and other countries, and suggestions regarding methods and lines of investigation which may usefully be followed by our stations are made in articles by the editors and by distinguished experts in the different specialties at home and abroad. A detailed subject and author index is published with each volume. As the condensed form of the Record makes its language necessarily somewhat technical, it is distributed only to such persons and institutions as make a special

request for it after examination of a sample copy. The fifth volume of the Experiment Station Record comprises 1,227 pages, and contains abstracts of 267 bulletins and 43 annual reports of 55 experiment stations in the United States and 67 publications of the Department of Agriculture. The total number of pages in these publications is 17,161.

There are also 227 abstracts of reports of foreign investigations. The total number of titles abstracted is 973, classified as follows:

Chemistry	46	Seeds	16
Botany	42	Weeds	8
Bacteriology	4	Diseases of plants	66
Zoology	6	Entomology	74
Mineralogy	1	Foods and animal production	119
Meteorology	36	Veterinary science	18
Water and soils	36	Dairying	89
Fertilizers	72	Agricultural engineering	18
Field crops	155	Technology	4
Horticulture	84	Statistics	69
Forestry	10		

Classified lists of titles of foreign articles not abstracted are also given in each number. The aggregate number of titles thus reported is 1,514. Special articles contributed by eminent foreign workers in agricultural science were translated in the office and published in the Record. A notable feature of the fifth volume of the Record is a review of recent work in dairying, prepared by Dr. E. W. Allen, assistant director, which serves to show how large and important a feature of experiment-station work investigations on dairying are.

In connection with the exhibit of the experiment stations at the World's Columbian Exposition the office prepared a Handbook of Experiment Station Work, which contains a résumé of the publications of the stations during nearly twenty years.

The office is also engaged in the preparation of a card index of experiment-station literature, which is freely distributed to the agricultural colleges and experiment stations, and is sold to a limited number of subscribers, the price covering the expense of printing the cards. Other indexes of the literature of agricultural science are prepared in the office for use in its work. So far as practicable, these indexes will be made available to station workers and other investigators.

Schedules for the financial reports of stations, as now required by Congress, are prepared in this office, and the office will also make an examination of the work of the stations as the basis of the report of the Secretary of Agriculture to Congress regarding the expenditures and work of the stations.

Congress having recently given the Department an appropriation for investigations on the nutritive value of human food, the supervision of this work has been assigned to this office, and the investigations will be carried on in cooperation with the agricultural colleges and experiment stations.

WHAT METEOROLOGY IS DOING FOR THE FARMER.

By MARK W. HARRINGTON,
Chief of Weather Bureau, U. S. Department of Agriculture.

Early in 1891, in view of the impending transfer of the meteorological work of the Government from the Signal Service to the newly created Weather Bureau, and without any suspicion that he would be called on to carry out his own suggestions, the writer published in the American Meteorological Journal a programme of improvements and expansions in the work. These were made with especial reference to the needs of farmers, and related to the following points: The improvement of the forecasts—their more complete distribution, especially to the farming communities; the general dissemination of information about the Weather Bureau—its objects and methods, what could or could not be properly expected of it; the compilation and publication of the climatic data of the United States, especially the data of use in the practical pursuit or study of agriculture—permitted by the accumulation of twenty or twenty-five years of observations of uniform character; the study of the scientific theory of meteorology with especial reference to the improvement of its practical application.

IMPROVEMENT OF FORECASTS.

That there has been an improvement in the forecasts is best shown by the increased popular approval indicated by the comments made on the Bureau by the press, by office correspondence, and by the increasing list of actual services performed in the cases of great storms. This is the result of several changes introduced into the administration of the Bureau. In the first place, there were only four expert forecasters in the Weather Bureau at the time of the transfer (July 1, 1891). There are now perhaps forty good ones, and of these there are from half a dozen to a dozen who are of very high grade. This has been accomplished by putting all of certain grades of employees, and every other employee who wished it, through a rigid course of practice forecast work at the central office, by making promotions depend on competitive tests in forecasts, and by recognizing by promotion cases of especial success in this work. The last two ideas were introduced by the present Secretary of Agriculture and have had great influence in fixing attention on forecasting as the chief duty intrusted by law to the Weather Bureau, and in increasing at nearly every station in the service the watchfulness and alertness of employees. Furthermore, the forecasters were

given more freedom in the verbal expression of their forecasts, thus releasing them from the hard and fast lines in which the former methods of verification had bound them, and enabling them to express their forecasts for the benefit of the public rather than for the benefit of their official records. The time predicted for has been extended, making it for the next day in each of the bidaily forecasts published, thus covering thirty-six hours instead of twenty-four. Moreover, careful and systematic studies are now pursued in the Forecast Division, the purpose of which is exclusively the improved usefulness of the weather map in weather prediction. Mechanical improvements to increase speed and accuracy in making the weather maps have been adopted, and all new devices which promise improvement in this direction are carefully tested with reference to their adoption.

THE DISTRIBUTION OF WARNINGS.

The distribution of warnings has been improved, but there is yet room for enormous expansion. The problem really involved is to place the bidaily forecast before each citizen who wishes it, and this may include very great numbers who are not within timely reach of the daily papers. For this purpose both visible and audible signals are used, and bulletins are posted at public places. The chief difficulty lies in transmitting the forecasts to isolated points in time to be of service. This has been much aided by gentlemen of great public spirit, often postmasters and editors, who, by means of an ingenious series of rubber stamps, rapidly duplicate the forecasts they receive and make local centers of distribution for outlying points, and this at an insignificant expense to the Government. The practice of urgency warnings has been very much increased and put on such a footing that any thickly populated district or frequented coast may be promptly and fully warned of the approach of disastrous meteorological changes. The problem of reaching, effectively and in time, the more sparsely settled districts is still unsolved. For instance, how can we tell the isolated overseers of cattle ranges in Wyoming of the approach of a blizzard? A scheme for the use of rockets has been suggested, but it does not fully meet the requirements.

DISSEMINATION OF INFORMATION REGARDING THE WORK OF THE WEATHER BUREAU.

For the dissemination of information concerning the work of the Bureau there has been employed every agency that presented itself—newspaper articles, lectures, public expositions, the most broad and general distribution practicable of the weather map, the encouragement of its use in schools, etc. The development of interest is especially noteworthy in the schools, where the daily interpretation of the weather map is becoming common. The annual issue of the weather map is

about 3,000,000, and this is nearly the full capacity of our present appliances; but this number would be doubled were we able to honor all the demands made on us for this characteristic publication, forming as it does the basis of our work and the chief means of our usefulness.

THE COMPILATION OF CLIMATIC DATA.

Though a knowledge of the climatic character of a region is one of the most important elements in estimating its agricultural capacity and possibilities, the compilation of the climatic data has gone on very slowly and with infinite difficulty. The number of observations involved is so enormous, the necessity for accuracy so increases the amount of work, and after the compilation the reduction of the results into a lucid form, capable of easy reference, is itself so slow a process, and such work seems so suitable to be displaced by other work more urgent but less important, that progress is very slow. Nevertheless, in Bulletin C of the Bureau there is presented the compilation of the data relating to rainfall, and work is progressing on the compilation of the statistics of humidity. To indicate the quantity of work involved it may be stated that the humidity compilation is estimated to require the copying out of 60,000,000 figures now scattered through the records of twenty-five years, and that after copying they must be verified, arranged, reduced, and averaged, five distinct operations on this mass of figures. When the humidity compilation is completed it is proposed to take up the temperatures, and with that the three elements most important to enlightened agriculture (viz, rainfall, humidity, and temperature) will be completed.

THE SCIENTIFIC THEORY OF METEOROLOGY.

Real, permanent, and marked progress in any art depends on the knowledge of the principles involved, and in such an art as weather forecasting this knowledge can be obtained only by scientific methods. The relations of terrestrial magnetism to weather changes have long been thought to be intimate, and competent students have from time to time made brief studies of them. The prolonged study of them by a very competent member of our force will soon enable us to tell just how intimate are the relations in question. Again, the soil presents meteorological relations of great interest. The Weather Bureau follows the precipitation to the soil and might go farther and study its distribution in the soil. The study itself, however, leads to certain physical and chemical developments which go somewhat far afield from meteorological methods, so that the soil subdivision of this Bureau is about to become an independent division of the Department. The relations of climate to crops and those of the stages of the seasons to the stages of plant life have received a good deal of attention, though in a somewhat desultory way.

The details of the phenomena occurring when the vapor in the air condenses to form raindrops, snowflakes, hailstones, or cloud elements are very imperfectly known, though of great importance in meteorological theory. We have published the results of one series of brilliant researches on this subject, and another is now (February, 1895) going through the press. They afford indications of some, in part, unexpected but very important laws which are involved.

Meteorological theory is turning more and more toward the idea that further material progress in the science depends on a more exact knowledge of what occurs in the higher air. This can be investigated by mountain observations and by balloons or other methods of reaching the free air. Nearly all government meteorological services have, therefore, one or more mountain stations, and even so low an elevation as the top of the Eiffel Tower (1,000 feet) in Paris has proved to be of considerable value. The Weather Bureau reestablished the station on the top of Pikes Peak, but was able to continue it for only two years, when it was discontinued, and the observations now await discussion.

PRESENT AND PROPOSED LINES OF WORK.

The work of forecasting floods is intrusted to the Bureau by the statute which organized it. This duty was first intrusted to one official, not a regular forecaster, but later was deputed to the Forecast Division, and finally also to individual forecasters and observers along the rivers in question. The science has now reached a point where it needs more detailed and precise information about the individual river basins, their contours and slopes, the possible backwaters of the rivers, their capacity at various stages, the more or less permanent bodies of snow which form their sources, the relation in time and height between quantity of rainfall in the basin and the stage of the stream, etc. These matters, so far as the data are collected by the Bureau, are now to be collated, systematized, and printed, when the path for further advance will become more clear.

Latterly, at the instigation of the Secretary of Agriculture, the collection of climatic data for the use of sanitarians has been undertaken. This appears to open up a broad field of usefulness.

The systematic study of clouds on new and revised principles has been undertaken by all government meteorological services in concert, and the Weather Bureau will undoubtedly take its share of the work involved.

Finally, the problem of forecasts for seasons is receiving continued attention from meteorologists, and recent developments indicate that hope of success in that direction is not so quixotic as it would have appeared five or ten years ago. It is quite possible, in the light of our present knowledge, that such forecasts, of sufficient accuracy to be of use, can be made before many years have passed.

THE VALUE OF FORECASTS.

By H. H. C. Dunwoody,

Assigned as Assistant Chief, Weather Bureau, U. S. Department of Agriculture.

DIVERSIFIED INTERESTS AFFECTED BY FORECASTS.

It is the object in the following pages to set forth as briefly as possible the diversified interests affected directly by the forecasts, and to give some approximate values of the benefits accruing from judicious use of the same. The task is not an easy one, because the interests "indirectly" benefited may often exceed in number and commercial importance the interests "directly" affected. Again, as a general thing, a severe atmospheric disturbance affects an area greater than that occupied by any one community or interest, and the returns from one or two communities for any one storm may not fully represent the benefits received. Again, of the smaller storms, it may happen that several prevail at nearly the same time. In such cases losses in outlying districts may escape record. Thus, on February 9, 1894, no less than 60 tornadoes were reported in various parts of the United States, including Mississippi, Tennessee, Kentucky, Illinois, Indiana, Ohio, Virginia, North Carolina, South Carolina, and Georgia. It is estimated that on that day some 10,000 buildings were destroyed and 2,500 people injured. This estimate, however, is but an approximate one, for there undoubtedly occurred great losses in localities distant from centers of communication which in the general havoc and distress might easily pass without notice.

INTERESTS DIRECTLY BENEFITED BY FORECASTS.

Mention will first be made of some of the many interests benefited directly by forecasts, of both the ordinary and emergency character. After these will be given instances of great savings by special warnings, then statistics of the value of cold-wave and frost warnings, and finally extracts from the annual reports of various stations giving instances of special benefits noted during the year. The value of the forecast in agriculture is self-evident, and at times of harvest, when the labors of the year may be wasted in a day, the importance of the forecast is strikingly noticeable. The general questions of crop yield in

their relation to rainfall, temperature, etc., are treated elsewhere by themselves and may be passed over here.

Bankers and brokers appreciate and watch closely the forecasts. Obviously whatever affects crops, commerce, or business industry affects them. Commission merchants and shippers of produce of a perishable character find the forecasts of the greatest assistance. In February, 1894, a responsible officer of one of the large beef-shipping companies stated that the forecasts were of the greatest help in locating and facilitating the running of beef cars between cities. The cars are regulated by the forecasts of temperature. The protection of fruits, vegetables, and food products from injury by heat or cold during transportation is of such importance that the subject has been specially investigated. A car load of fruit, even after it has started, may be detained at some point on the way and thus escape extreme and trying temperatures. Besides regulating the temperature of freight cars, the forecasts are used, especially on through trains, in regulating the temperature of passenger cars. The following quotation from a letter dated February 7, 1894, illustrates the practical use of the forecasts in this direction: They "enable us to regulate the length of our trains, to arrange for extra fuel supplies, to take precautions in the care of engines and prevent freezing of water supply, etc." Engineers, in many ways, put the forecasts to use. In maintaining equable and comfortable temperatures in large office buildings, for example, the forecasts are of the greatest value.

The Johns Hopkins Hospital, at Baltimore, Md., covers perhaps as large an area heated from a single furnace room as can be found. The problem of heating and ventilating so many wards and rooms is far from being an easy one. Much is at stake; indeed, sometimes the recovery, comfort, and life of the patient, the successful crowning of the work of physician and nurse, depends upon this preservation of proper temperature. If it can be done in a large hospital it can be done elsewhere. Dr. Henry M. Hurd, the superintendent of the hospital, says:

> This will give a good idea of the systematized method in use here for keeping a combined coal and weather account. There is a very direct relation between the outside temperature and the amount of coal consumed. The reports which are received from the Weather Service are of great benefit to our engineer, as by means of the prediction it is possible to give directions as to the amount of hot water which will need to be carried in order to make the heating of the wards absolutely uniform. You will notice from the temperature of the different wards that the variations are very small. This is largely due to the fact that it is possible in many instances to prepare for changes of temperature by carrying hot water at a higher or lower temperature.

Nor is it only in large hospitals that the forecasts can be thus systematically and profitably used. They can be utilized with great good by the individual physician. He will be better qualified to advise precautionary measures for the ensuing day in the way of clothing, occupation, and regimen.

THE STORM OF MARCH 27, 1890.

In an official report of the board of trade relief committee of one of our large cities, in almost the opening paragraph, appears this statement:

> In the afternoon papers of that date (March 27, 1890) there appeared from the Weather Service at Washington a notice of warning of severe local storms and atmospheric trouble in Louisville and vicinity. Shortly before the tornado there came a heavy rain, followed by a hailstorm accompanied by severe lightning. The wind began to blow with a mournful sound, which soon increased to a frightful shriek as it swept over the doomed portion of the city. The calamity occurred about 8.30 p. m., and was over in a few minutes.

This tornado destroyed in a few moments 5 churches, the union railroad depot, 2 public halls, 3 schools, 266 stores, 32 manufacturing establishments, 10 tobacco warehouses, and 532 residences in the city limits only. The pecuniary loss was estimated by these gentlemen of the board of trade, after careful tabulation, at $2,150,000. There were 76 lives lost and over 200 people injured by the catastrophe. Such a calamity can be paralleled only in some convulsion of nature, fortunately of infrequent occurrence, such as an earthquake, a volcanic eruption, or a great tidal wave.

THE "SEA ISLANDS" AND "TROPICAL" STORMS.

The storm of August 26, 27, 28, 1893, familiarly known as the "sea islands storm," with the accompanying rise in the waters, resulted in the loss of nearly 1,200 lives. The story of the devastation caused by that storm has been graphically told in the popular magazines, but anything like a careful estimate of the actual damage has never been published. The value of the warning likewise can not be estimated. It may be, though, that the remembrance of this storm had much to do with the ready appreciation of the warnings given this year. So widely disseminated were these latter warnings, and so promptly and intelligently were they utilized in the warned communities, that the Weather Bureau can show in the case of the tropical hurricane of September 24–29, 1894, that 1,089 vessels, valued at $17,100,413, remained in port. In the hurricane of October 8–10, 1894, 1,216 vessels, valued at $19,183,500, heeded the warning. Within, then, a period of little more than two weeks the forecasts and warnings of the Bureau were instrumental in saving 2,305 vessels, valued at $36,283,913, or, to be somewhat more accurate, but for the warnings these vessels would probably have gone to sea, and it is but fair to presume would in such event have met with disaster. The records show that in very many instances where the warnings were disregarded heavy losses were incurred. Even these amounts, vast as they are, are but portions of the whole, for, as happened in both of these storms, ripening crops, accumulated stores and supplies, goods gathered for shipment and goods in transit were removed from exposed places to points of safety.

In calamitous storms of the types referred to it is customary to promptly institute measures of relief. No work is nobler. Surely the duty of giving warning of impending danger, antedating relief work, and giving all an opportunity to help themselves and others, is noble work, too.

Tornadoes and West Indian hurricanes are not the only atmospheric disturbances destructive to life and property. Though the loss of life is perhaps less, the destruction of property by severe wind storms, heavy washing rains, scorching hot winds, severe cold waves and frosts, being of more frequent occurrence, amounts in the aggregate perhaps to a sum in excess of the figures given.

THE SAVING OF PROPERTY AND LIFE.

Successful application of the forecasts, then, as the foregoing cases show, is quite possible and by no means rare. They can be made of service in almost every occupation of life. They can be made to contribute to comfort or utilized in saving property and protecting life. The value of the forecasts in this last respect is strikingly shown at times of West India hurricanes and in less degree in some of the severe inland storms which sweep over the Great Lakes. The value of the warning of the gale of September 22–24, 1894, is well shown by the list of vessels held in port:

Bay City	1	Sheboygan	4
Charlevoix	6	South Haven	5
Cheboygan	1	Sturgeon Bay	23
East Tawas	5	Lake City	1
Houghton	2	Holland	3
Kewaunee	5	Marquette	4
Kenosha	5	Grand Haven	1
Ludington	5	Alpena	14
Manistee	20	Port Huron	28
Menominee	3	Chicago	30
Mackinaw City	16	Sault Ste. Marie	27
Muskegon	4	White Fish Point	20
Sand Beach	26		
Saugatuck	1	Grand total	260

In the city of Chicago the owners of the steamer *City of Chicago*, ready to sail with 400 passengers and cargo valued at $15,000, detained her in port for twenty-four hours. The Lehigh Valley Transportation Company held their steamer *Saranac*, bound for Buffalo with 2,400 tons of merchandise, until word was received that the storm was abating. Instances of this service could easily be multiplied. At the life-saving station the crew were given all information relative to the storm, and extra precautions were taken by the watcher on the tower, which resulted in the saving of the lives of four persons. The tug watcher, who is employed by all the tug companies and is in telegraphic communication with the tug offices, had copies of the warning given to tug captains and had one of the tugs steam out and warn the schooner

Libby Naw, the schooner *Michaelson*, and the light-house supply boat *Dalia*. These boats were heavily laden and were outside of the port. Upon receiving the warning they got into port without delay and escaped the storm. Inquiry at the clearance depot of the United States custom-house showed that about 50 vessels had taken out clearance papers on Saturday, and of these boats over 30 heeded the storm signal and came to anchor inside the breakwater, where the effects of the storm were less felt. In one case where the signal was disregarded the steamer stranded at Grand Haven. There are numerous cases where mishap has followed a disregard of signal. Along the lakes also warnings of severe cold waves are of great financial value. Thus during the early frosts of the season of 1891, just at harvest time, when the wheat crop of northern Dakota and northern Minnesota required a week or ten days to mature, extensive preparations were made by the farmers to avert injury from frost. Material for smudge fires was collected and made ready to be fired upon receipt of the frost warning. Through the cooperation of the telegraph service of the Great Northern and the Northern Pacific railroads, the warnings were widely disseminated, and at the proper time the fires were lighted, and many million bushels of wheat saved. This in the far North. In the far South, in the same season, 75 per cent of the vegetable and fruit crop was protected by smudge fires kindled at the approach of cold weather.

Not of the least importance are the forecasts to canal interests. A large raft of lumber, for instance, is passing through a canal into a river. Warning of a cold wave is received; the raft is drawn back into the canal and thus saved from being cut to pieces by the running ice. Cattle men find the warnings of great value. Cranberry growers, as a class, have special warnings sent to them. Fuel companies, as might be expected, find it to their interest to watch carefully the forecasts. At Pittsburg the shipment of coal by river, amounting to many million dollars, is, to a large degree, controlled by information received from the Weather Bureau. In 1890–91 ice was harvested before it had reached the average thickness because of warning of a thaw.

The forecasts of the Weather Bureau may not always be as fully verified as the conditions upon which they were based promised, but the value of forecasts verified at least eight out of ten times can not be deprecated at any time, and when special warnings are sent in times of emergency the value is fittingly expressed by the word "incalculable."

EXTRACTS FROM ANNUAL REPORTS OF VARIOUS STATIONS.

The extracts which follow are taken from the annual reports of the stations enumerated, and furnish convincing evidence of the practical value of the forecasts of the Weather Bureau to agriculture, as well as a variety of other interests affected by the weather:

From the annual report of the station at Nashville, Tenn.:

The cold-wave warnings are probably worth $50,000 to the State.

From the annual report of the station at Savannah, Ga.:

It is estimated that the money value of property saved by the cold-wave and frost warnings during the past year was between $20,000 and $25,000. The warnings have, as a rule, given general satisfaction.

From the annual report of the station at Wilmington, N. C.:

When it is known that the strawberry crop of eastern North Carolina for this year was between $250,000 and $300,000, it is thought, and without any attempt to exaggerate, that the money value of this crop saved by the cold-wave warnings is at least $25,000.

From the report of the station at New York City, N. Y.:

It would be difficult to estimate, with any assurance of correctness, the real money value of perishable goods and in other ways the saving by the cold-wave warnings; but I do not think $1,000,000 would be the full amount.

From the annual report of the station at Milwaukee, Wis.:

It is believed that it is a conservative estimate to state that the amount of money necessary to support this office is in each year saved many times over to the commission merchants by the information furnished them daily.

The frost warnings from this office continue to give satisfaction to the public and to materially add to the popularity of the service. The president of the Wisconsin State Cranberry Growers' Association stated before the association, at its annual meeting last January, that rather than do without these warnings he would pay the expense of telegraphing out of his own pockets; that at one time during the past year he was waiting for the train at his station, prepared to leave on important business, but when the train came in it carried a frost signal; that he returned to his large marsh, 7 miles distant, ordered the reservoirs opened, and saved several thousand dollars' worth of berries from destruction by frost the following morning.

From the annual report of the station at Columbus, Ohio:

As this point is the principal produce-shipping point of the State, I have no doubt that the value of the shipments saved by the cold-wave warnings during the season was close to $500,000.

From the annual report of the station at Charleston, S. C.:

A safe and truthful estimate of the money value of property saved to this community this year is fully double that given for last year, as the warnings were disseminated to a more marked degree than in any other year previous, footing up $350,000. This is exclusive of the frost service rendered during February, March, and April of this year, for the benefit of those who raise early beans, peas, beets, cucumbers, lettuce, potatoes, onions, squash, and corn for shipment to Northern markets.

From the annual report of the station at Cape Henry, Va.:

Marked benefits result from the work of this Bureau, as in the case of the steamship *Rappahannock*, Chesapeake and Ohio Line, which vessel went ashore at a point near this place at 7 p. m., January 22. The agents of this line were notified and wrecking companies called on for assistance, which was immediately furnished; on the 24th information of a cold wave and high westerly to northerly winds was flagged by this office to the stranded vessel. The wreckers redoubled their efforts in lightening her cargo so she would float at high-water tide, which she did at 10.35 p. m. An unusually severe northerly gale, with cold weather, rain, and a very high sea, set in at 12.45 a. m. the 25th. Had the *Rappahannock* not floated on the last high

tide, it is conceded by everyone that vessel and cargo would have been a total loss. The vessel and cargo, valued at $600,000, were undoubtedly saved through the efforts of this office in getting the weather reports to the stranded steamer.

From the annual report of the station at Dodge City, Kans.:

There was about $5,000 worth of stock saved last winter by the cold-wave signals. The value of the fruit saved is very hard to determine; a conservative estimate places it anywhere from $25,000 to $50,000.

From the annual report of the station at Alpena, Mich.:

The island telegraph lines have been in successful operation since July 14, 1893, and have rendered great assistance to maritime interests. Their value is being recognized by all vessel men. They have been used frequently since their completion by vessels in distress, and it would be no exaggeration to say that they have fully paid for the money expended in their construction and maintenance. With few exceptions there has been uninterrupted communication. The Middle Island line was exceptionally beneficial to Gilchrist & Fletcher, of this city, during May 1894, whose raft of three and one-half millions went ashore near Middle Island. The line was used frequently every day for a week and much assistance rendered by it. Mr. Gilchrist visited the office during the time and spoke of the great benefit received from this service. Not a stick of the raft was lost, such an unusual occurrence that comment was made about it in the Detroit daily papers.

From the annual report of the station at Baltimore, Md.:

An example of great benefit received was instanced by a Baltimore and Ohio Railroad official. A train loaded with wet sand was waiting upon a siding, and, as it was not to be used for two or three days, the necessity for unloading was not considered immediate. A cold-wave warning was received, and the cars were emptied as quickly as possible. Had this not been done without delay, the sand would have been frozen in the cars and could not have been unloaded for several weeks, as the cold spell was unusually severe and long.

From the annual report of the station at Norfolk, Va.:

The total estimated value of property saved by cold-wave warnings is from $30,000 to $40,000.

During the severe storm of last August the timely storm warnings issued by the Weather Bureau were of inestimable value to the vessels then ready to proceed to sea, as many of these vessels remained in port on account of the warnings given, and rode out some of the severest gales which have been experienced along the Atlantic coast in many years. Without these warnings possibly nine-tenths of these vessels would have proceeded to sea, and in all probability would have been lost.

The reporting of passing vessels in and out at Cape Henry is one of the most important features of the seacoast line, and this work is worth thousands every year to the steamship lines running to and from Norfolk, as an incoming steamer is reported to the agent from two to three hours in advance of her arrival at the dock, thus enabling them to have everything in readiness on her arrival, and by this means effect a great saving of time, which is worth everything to those carrying mostly perishable freight.

From the annual report of the station at Montgomery, Ala.:

The cold-wave warnings of January 23 and February 11, besides being distributed by great numbers of bulletins by hand and through the mails, and published in local newspapers, were, in addition to being telegraphed to all displaymen, telegraphed at Government expense to postmasters of twenty surrounding towns, and from reliable information it is thought that these warnings, even though early in the season, saved

at least $25,000 to farmers in this State. The warning of March 25, at a low estimate, saved $50,000 to the truckers of this section, and would have saved more had it come any other day than Sunday, which is a bad day for distributing information. It is safe to say that the money value saved to agriculture and shipping interests in this State by these warnings during the past year, if fully known, would aggregate over $100,000.

From the annual report of the station at Louisville, Ky.:

The warning of January 23 was one of the most beneficial to this section ever made in the Weather Bureau. It was of especial value to the railroads, which at the time had a large amount of perishable freight on the way from the South, and much of which was protected through the warning.

The most important instance in which the records figured during the past year was that of the Phœnix Bridge Company, which claimed that the destruction of two of the piers of the bridge being built by it was due to a tornado, and not to faulty workmanship, as alleged by its opponents. This case, in which several hundreds of thousands of dollars are involved, has not yet been settled, and the Weather Bureau records will have a most important bearing upon its final adjustment.

From the annual report of the station at Memphis, Tenn.:

My attention was called to a case which happened several years ago which has probably not been reported. M. E. Carter & Co., of this city, had an order for eight car loads of potatoes to be shipped to points in Arkansas. Just before they began to load they called up the Weather Bureau and were informed that an extensive and severe cold wave was approaching, and were advised to hold the shipment over till Monday, this being Friday. They had one car partly loaded and they decided to risk this one car. The result was that every potato in the car was frozen. The other seven cars were held over and reached their destination in safety. Mr. Carter stated to me that they calculated the value of the seven cars at $2,150, all of which they considered saved from the warning of the Weather Bureau.

From the annual report of the station at Kansas City, Mo.:

The observer is unable to place a money estimate on the value of this service. A very conservative estimate would place it at $50,000, but there are such a variety of interests affected it would be impossible to give an intelligent estimate. Fruit and produce men place it in the neighborhood of $50,000.

From the annual report of the station at Buffalo, N. Y.:

The records at the station show that not a single storm of any character passed over the station during the year, especially in the fall, without ample warning having been given at least twenty-four hours in advance. The warnings given were heeded by all classes of marine men. Notwithstanding the close proximity of the central office of the Canadian Meteorological Bureau at Toronto, during the closing months of navigation daily requests by telephone and telegraph for wind forecasts were received from Canadian sources.

On November 24 special forecasts were issued to the marine men, informing them that all vessels weather bound here during the past ten days would have fair sailing weather to-morrow, and orders were given to get ready to clear. The Buffalo Courier, commenting on same, said, Sunday, November 26: "The large fleet of vessels which has been sheltered behind the breakwater for a week or more was able to leave port. The forecasts of Friday came true, the storm abated, and by noon yesterday nearly all the storm-bound vessels were out of sight." These vessels had been held in port by the storm warnings.

SOILS IN THEIR RELATION TO CROP PRODUCTION.

By MILTON WHITNEY,
Chief of the Division of Agricultural Soils, U. S. Department of Agriculture.

TRUCK LANDS OF THE ATLANTIC SEABOARD.

Truck farming has existed as a separate agricultural industry for about thirty years. Previous to that time fruits and vegetables were grown in gardens and as part of the regular farm crops on all well-regulated farms, and in market gardens within a few miles of the larger towns and cities. People were content then to have the fruits and vegetables in the ordinary season in which they matured in their immediate locality. In recent years, however, transportation facilities have wonderfully improved, and the growing of fruits and vegetables for the early markets has developed into a distinct and special branch of farming.

A few years ago tomatoes were not expected in the Baltimore markets until the local crop ripened in July. During the winter and spring canned tomatoes were extensively and almost exclusively used. Now, however, the Florida crop of fresh tomatoes begins to arrive in the Baltimore market early in January in a fresh and healthy condition, as it requires only twenty-four or thirty-six hours for transportation—hardly longer than is required to bring the local crop on schooners and sloops from the lower estuaries of the Chesapeake Bay. These early tomatoes sell readily for 50 or 75 cents per dozen at the same time that Florida oranges are bringing from 15 to 30 cents per dozen, and while canned tomatoes are selling for 10 or 15 cents for a 3-pound can. This is followed by successive crops from Georgia, the Carolinas, Virginia, and the local crop of Maryland. The season for fresh tomatoes in the Baltimore market thus extends over fully nine months in the year. The same is true of other vegetables. There is a very great and increasing demand for these early vegetables, as they are put on the market in much better condition and at a lower cost than ever before, and families of very moderate means can afford to purchase them.

SOME ESSENTIAL FACTORS OF SUCCESSFUL TRUCK FARMING.

The conditions necessary for the success of this special industry of truck farming, in addition to personal qualifications and sufficient working capital, are favorable climatic conditions, light, sandy soils, in which the vegetables can be planted early, and which will force them

to an early maturity, and quick, direct, and safe transportation facilities, with arrangements for through cars, and refrigerator cars where these are necessary.

The early truck is grown upon a peculiar class of very light, sandy soils. These soils extend along the Atlantic coast for a distance of about 1,500 miles in a narrow strip bordering the coast, bays, and rivers from Massachusetts to Florida, the line running approximately northeast and southwest. The season advances northward along the coast at the average rate of about 13 miles per day. Lands located 100 miles south of Norfolk have the advantage of about a week in the maturity of the crops, thus commanding a higher market price, so that the truckers can afford the higher freight rates for the longer distance their products have to be hauled to the Northern markets. Similar land situated an equal distance west of Norfolk, with no direct connection with the North except through Norfolk, would have no advantage over the Norfolk crop by reason of the climate, and the added cost of transportation would make trucking unprofitable. A railroad, therefore, running north and south has a great advantage in developing local trucking interests over one running east and west. The high prices, due to lack of competition in the early market, afford the truck crops an opening northward without which the demand would be limited to the local market, but with the advantages of climate, quick soils, and lack of competition from the heavier and richer agricultural lands, these crops are sent to almost any point in the United States or in Canada with profit.

Land situated immediately on a railroad is worth several times as much as similar land situated 2 or 3 miles away, on account of the difficulty and expense of transporting the tender and bulky crop and the damage done in handling and hauling. The same is even more marked in the case of land situated immediately on the water, partly on account of its relation to transportation and partly from its freedom from frost. The influence of the proximity to the water is very marked in the early spring. Crops a quarter or a half mile inland may be injured or destroyed by frost while those immediately adjacent to the water are not affected. For this reason crops may be planted earlier in the spring on land near water, and consequently will mature earlier on stiffer soils at the end of a river neck, with water on two or three sides, than they will mature on soils of the same or even of lighter texture farther inland. These points must all be considered in judging of the suitability of a soil for truck farming.

The total area devoted to truck farming in the United States in 1889, exclusive of market gardening, was, according to the Eleventh Census, 534,440 acres. Of this about 61.31 per cent was located along the Atlantic Seaboard, distributed as shown in the table below. The "peninsular district" here includes the Eastern Shore counties of Maryland and Virginia, together with the State of Delaware.

The following table gives the acreage of the principal truck crops along the Atlantic Seaboard:

Acreage and value of land and truck products on the Atlantic Seaboard.

District.	Number of acres.	Per cent of total truck area in United States.	Value of land per acre.	Value of truck products.
New York and Philadelphia	108,135	20.23	$226.11	$21,102,521
Peninsular	25,714	4.81	98.76	2,413,648
Baltimore	37,181	6.93	97.50	3,784,696
Norfolk	45,375	8.49	135.50	4,692,859
South Atlantic	111,441	20.85	45.25	13,183,516
Total	326,816	61.31		45,177,240

To produce this truck a very intense system of cultivation is practiced and the expense of making the crop is very great. The value of the land ranges from $40 to $500 per acre, depending upon the soil, location, distance from market, and transportation facilities. Their average value may be placed at about $200 per acre. Before they were used for truck farming they were worth no more than from $1 to $5 per acre. Even now, when they are remote from transportation lines, good truck lands can still be purchased for this sum. The cost of labor on the different crops ranges from about $10 to $30 per acre; the cost of seeds and plants from 50 cents to $10 per acre, depending upon the kind of vegetable. The fertilizers cost from $10 to $50 per acre, while individual planters use as much as $60 to $75 worth of high-grade fertilizers per acre. Very conservative estimates place the necessary working capital for a small truck farm at from $6,000 to $20,000. One large firm in eastern North Carolina claims that it requires $40,000 a year to make its crop.

These figures show that truck farming is an industry in which a large amount of capital is invested and which carries great risks. A successful truck grower requires a large capital as compared with what is needed for general farming, while the risks are as great and the enterprises are quite as heavy as in ordinary commercial or industrial lines. The man who risks $40,000 annually in any business, or even a capital of $20,000 or $6,000, must be cautious and must understand very well his conditions, opportunities, and powers.

Truck farming may be started on a very small scale, as with any other industry, but competition is so sharp and the margin of profit has become so small, while the risks are so great, that there is a distinct tendency among the larger planters to form combinations which make it more and more difficult for the smaller truckers to succeed. In this as in other industries a large planter can work on a narrower margin than a small one, providing the enterprise is not too great for him to carry with his available capital.

Truckers' associations are being organized in local centers, which receive daily market reports during the growing season from the principal markets and distributing points throughout the United States and Canada. These organizations have very great power and influence, and as they understand and appreciate these more they will exercise far more influence upon the markets than they do now. Three or four of the large planters around Norfolk, by putting their potato crops suddenly upon the New York market, can depress the price to such a small margin of profit that the smaller dealers can not afford to sell. Indeed, it is no uncommon thing during the harvesting season for the price of potatoes in New York to fall $1 a barrel in the course of a day. The truckers' associations try to distribute the crops through the different markets in the North and West so as to maintain uniform prices, and as they become better trained in their responsibilities and have a better appreciation of their powers and duties they will undoubtedly maintain more uniform prices than at present.

So close has competition become and so narrow are the margins of profit that it is stated that the difference of a cent a barrel on spinach in the present freight rates from Norfolk to New York reduces the price below the actual cost of production. The planters claim that they have such control over their crops and exercise such careful business methods in their production that the freight rates frequently determine the selling price, as is the case with many manufactured commodities.

Another factor which has had much to do with the success of truck farming has been the introduction of methods of canning or otherwise preserving fruits and vegetables for which there is no present demand, so they can be kept for winter use. This ability to preserve the crop has more than once saved the planters from what would otherwise have been disastrous seasons, when, as occasionally happens, the crops from a number of localities mature at the same time.

In truck growing an early maturity is essential to the profitable conduct of the business, and the yield per acre and quality of the crop are minor conditions. With wheat the yield per acre is the most essential factor and the quality or time of ripening is relatively unimportant; with tobacco the quality and texture of the leaf are the chief factors, and the yield and time of ripening are of less consequence; but with early truck the time of ripening is by far the most important feature.

Early maturity is very largely dependent upon the character of the soil. Light, sandy lands are most valuable for this industry because when properly treated the crop matures much earlier than on the heavy lands. The aim of the truck planter is to get the crop to market at the earliest possible moment, or else to delay it until the crops from the heavier soils of the State have all matured. The heavy grass and wheat lands will produce three or four times as great a yield of truck as the truck soils do even under the intense and expensive system of cultivation practiced. The latter, however, mature their

crops six or eight weeks earlier, and thus for the time are free from the competition of the richer soils.

The amount of clay present in these light truck soils has a very marked influence upon the development and time of ripening of a crop. The nature of the crop itself must be considered, of course, as all of the truck crops are not equally well adapted to the same kind of soil. Sweet potatoes and melons, for example, require a very light soil, containing but little clay, for they can not be forced well to an early maturity on the heavier soils. Cabbage and spinach, on the other hand, do better on the heavier soils and will mature about as early, for the reason that they can be planted in the fall and will stand the winter well on a soil containing from 8 to 12 per cent of clay in the subsoil, while they will not stand the winter so well on a soil containing less than 6 per cent of clay, which is the best soil for sweet potatoes and melons. Tomatoes will ripen a full week earlier on land having no more than 4 or 5 per cent of clay in the subsoil than they will on land having 8 or 9 per cent. They will do better and yield more per acre on the heavier land, but they are not so early and do not bring such high market prices.

With the qualification just made, soils having the smallest percentage of clay are invariably regarded as the earliest truck lands, except where heavier soils are situated directly at the point of a river neck and are thus earlier freed from frost, as already explained.

CONSTITUENTS OF TYPICAL TRUCK SOILS.

Typical truck soils of the Atlantic Seaboard contain from about 1 per cent to 12 per cent of clay in the subsoil. The lighter soils, or those containing the least amount of clay, are better adapted to the earlier and lighter spring vegetables, while the heavier soils are better adapted to the later and heavier truck and to those crops which can be planted in the fall for the early spring market. The conditions in a soil containing 10 per cent of clay in the subsoil frequently delay the planting of a spring crop from two to three weeks later than on a soil containing only 5 per cent of clay. The principal crops may be arranged as follows to show the kind of soil best adapted to them:

Sweet potatoes. Melons Asparagus Irish potatoes	Best adapted to lands having from 3 to 9 per cent of clay.
Tomatoes Peas Spinach Cabbage	Best adapted to lands having from 6 to 12 per cent of clay.

Soils having over 10 or 12 per cent of clay are too heavy and too retentive of moisture for the early truck crops. The yield per acre is larger than on the truck land, but it has to meet more competition. The whole value of the truck soils lies in the relation of these soils to moisture and in the relatively small amount of moisture they maintain

for crops. The soils are composed mainly of moderately coarse grains of sand and contain very little clay. The accompanying illustrations show the amounts of the different grades of sand, silt, and clay contained in 20 grams of two different types of truck land. The different grades of sand, silt, and clay were separated by sieves and by slow subsidence in water, and were put into small bottles and photographed.

The lighter soil, represented by figure 1, has only 4.40 per cent of clay. This is well adapted to the very early truck, such as sweet potatoes, melons, asparagus, Irish potatoes, tomatoes, and peas, but it is too light in texture for spinach and cabbage. The heavier soil, represented by figure 2, containing 9.16 per cent of clay, represents the heavier grade of truck lands, particularly well adapted to tomatoes, peas, spinach, and cabbage. It is too heavy for the earlier spring vegetables.

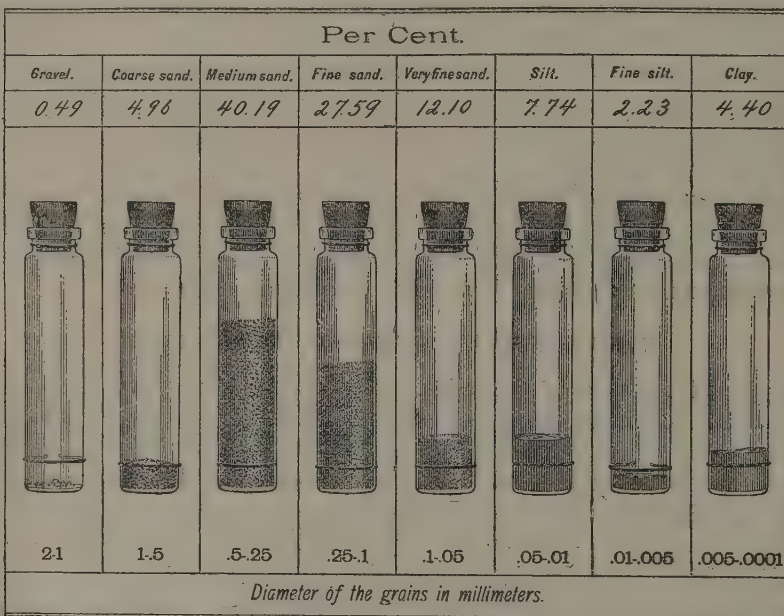

FIG. 1—Mechanical separation of the gravel, sand, silt, and clay in 20 grams of subsoil of the Columbia formation at Marley, Md., adapted to early truck.

Wheat can not be economically produced on these light truck lands, as the yield per acre under the best treatment would rarely exceed 5 bushels. A good wheat soil must contain at least 18 per cent of clay, unless, indeed, as is the case with many Western soils, they contain a large amount of silt. Still less can grass be economically produced on these light truck soils, for a good grass land requires at least 30 per cent of clay in the subsoil to make it sufficiently retentive of moisture, unless, indeed, water is supplied through artificial means. Within these light, sandy soils, upon which truck farming has been so successfully carried on, there is very little resistance to the descent of the rainfall, and the soil readily drains itself of all but a small supply of water. Grass and wheat lands, on the other hand, contain a large

amount of clay and very fine material, and offer a great resistance to the descent of the rainfall, and maintain an abundant supply of water.

As a basis of comparison, an illustration is given in figure 3 of the mechanical separation of the different grades of sand, silt, and clay in a heavy limestone soil of the Cumberland Valley, in western Maryland. This represents the very finest type of agricultural land for the staple agricultural crops.

It will be seen that this subsoil, which is adapted to both wheat and grass, has less than 5 per cent of sand, while a typical truck soil contains from 70 to 85 per cent of sand. If the same quantity of rain fell on this clay soil it would encounter such a resistance and there would be so much friction as it percolated through the innumerable small openings that the descent would be extremely slow and an abundant

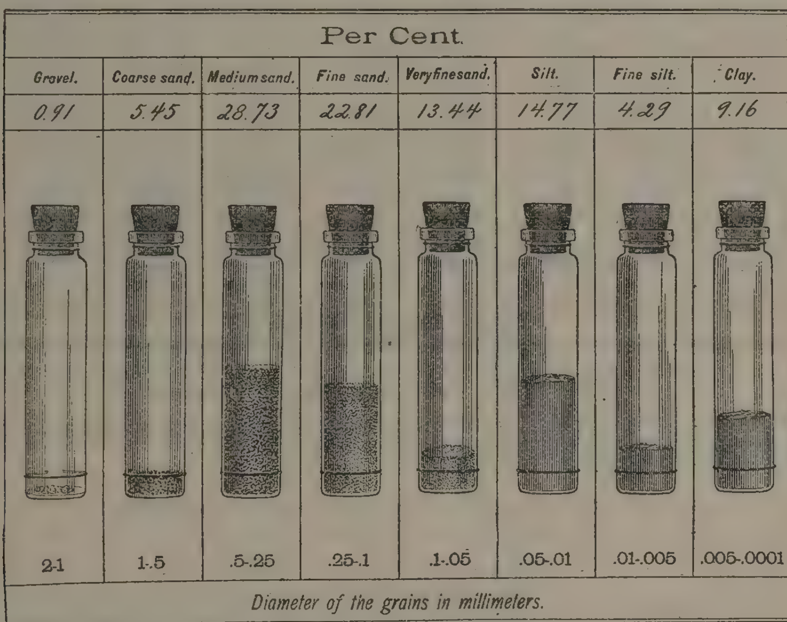

FIG. 2.—Mechanical separation of the gravel, sand, silt, and clay in 20 grams of subsoil of the Columbia formation at Marley, Md., adapted to cabbage and early truck crops.

supply of moisture would be maintained for vigorous vegetative growth of plants. On the light, sandy soils, maintaining a very limited supply of moisture, the plants, on the contrary, are thin textured, more succulent, yield less per acre, and are forced to a very early maturity. It is upon this fact that the success of truck farming ultimately depends.

Examinations have been made of the soils in a number of localities in the truck area of the Atlantic Seaboard, and the character of the soil devoted to truck has been found to be remarkably uniform. The influence of the texture of the soil on the distribution of the different truck crops is very marked. A brief description of the several localities, with analyses of some of the typical truck soils, will bring out these points very strongly, and will serve as a basis for the estimation of the adaptability of other soils in these localities for truck growing.

TRUCK SOILS OF FLORIDA AND SOUTH CAROLINA.

Only a few samples have been obtained of the truck soils of the far South. The mechanical analyses of three typical truck soils from

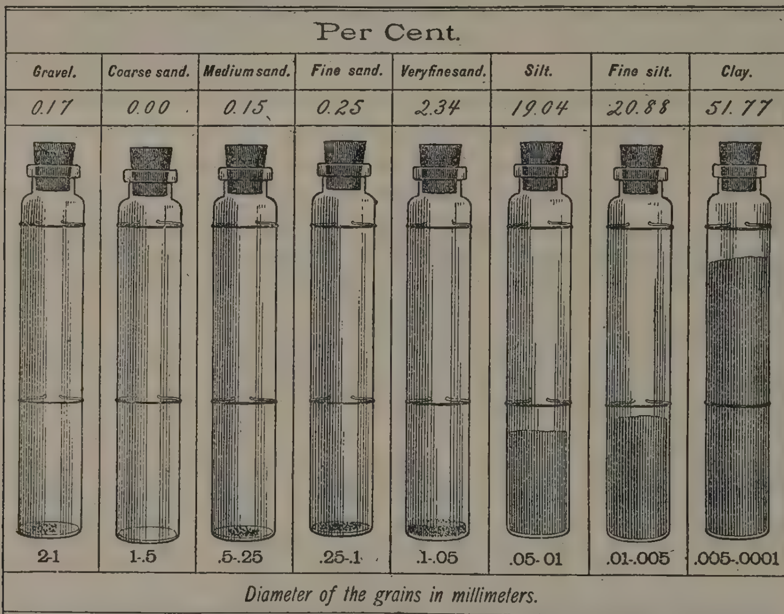

FIG. 3.—Mechanical separation of the gravel, sand, silt, and clay in 20 grams of the limestone subsoil from Frederick, Md., adapted to wheat and grass.

Florida are given in the accompanying table, together with the analyses of five soils from South Carolina.

TABLE 1.—*Mechanical analyses of subsoils of truck lands.*

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1mm).	Coarse sand (1-.5mm).	Medium sand (.5-.25mm).	Fine sand (.25-.1mm).	Very fine sand (.1-.05mm).	Silt (.05-.01mm).	Fine silt (.01-.005mm).	Clay (.005-.0001mm).
	FLORIDA.	*P. ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1622	Altoona, Etonia scrub	0.68	0.63	0.34	3.92	40.39	44.97	6.96	0.79	0.33	1.16
1624	Eustis, high pine land	0.25	0.66	2.74	11.70	42.05	35.29	4.50	0.88	0.56	1.23
1620	Altoona, high pine land	0.15	0.87	1.61	4.52	12.28	27.58	48.12	2.16	0.81	1.31
	SOUTH CAROLINA.										
78	Wedgefield	......	[1] 1.32	5.88	31.45	27.31	28.14	3.96		3.97	
86	James Island, sandy land	......	1.06	0.00	0.00	0.67	90.14	3.35		4.78	
88	James Island, "provision land"	......	1.65	0.00	0.88	2.50	82.97	6.30		5.70	
84	James Island	......	1.76	0.59	3.67	4.27	78.88	4.20		6.63	
82	James Island, "clay land"	......	1.62	0.00	0.54	1.03	83.20	6.44		7.17	

[1] The figures in this column were determined by difference, and include the total organic matter, moisture, and loss in the analysis.

It will be seen that the Florida soils contain very little silt, fine silt, or clay, the whole amount of these three grades being less than 5 per cent. They are extremely light-textured, sandy soils, adapted to the earliest spring vegetables. Climatic conditions in south and central Florida make it possible, of course, to produce outdoor crops throughout the winter, and these lands are well adapted to the forcing of that class of vegetables.

The samples from South Carolina differ more in their content of fine material. The sample from Wedgefield has considerable coarse sand, but very little silt and clay. This soil is particularly well adapted to sweet potatoes, melons, and the forcing of early spring vegetables.

Of the several samples from James Island, the sandy land (No. 86) is considered the earliest, and is better adapted to the forcing of the early spring vegetables. The clay land (No. 82) is better adapted to the heavier and later vegetables, particularly tomatoes, cabbage, and spinach.

Owing to the difference in the location and in the climate, the truck crops of Florida are practically all marketed before the South Carolina crops come on, and the latter are harvested before the North Carolina and Virginia crops mature.

TRUCK LANDS OF EASTERN NORTH CAROLINA.

The accompanying table gives the mechanical analyses of a number of typical truck lands in eastern North Carolina:

TABLE 2.—*Mechanical analyses of subsoils of truck lands.*

No.	Locality.	Organic matter.[1]	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	NORTH CAROLINA.									
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1510	Newbern, early spring truck	0.67	0.00	0.30	6.04	49.63	32.39	6.24	1.93	2.80
1524	Edenton	2.54	0.00	0.00	4.74	36.16	38.71	10.27	4.18	3.40
1534	Hertford	....	0.00	0.00	6.37	38.34	9.67	7.54	2.35	6.47
1566	Elizabeth City	3.14	0.00	0.00	4.94	6.11	43.61	25.73	7.27	9.20
1517	Newbern	1.57	0.00	3.91	22.60	29.03	22.38	7.03	3.16	10.32
1570	Camden	1.90	0.00	2.46	5.17	19.79	33.53	19.69	7.11	10.35
1542	Chapanoke	1.18	0.00	0.00	7.68	41.77	13.05	18.92	5.63	12.37
1514	Newbern, heavy cabbage land	1.70	0.00	2.04	10.57	10.65	22.75	30.22	8.95	13.12
1519	Elizabeth City	3.34	0.00	0.00	2.07	4.75	39.16	30.04	6.27	14.37
1522	Edenton, heavy truck land	2.35	0.00	1.13	6.11	20.58	27.82	18.37	7.79	15.85

[1] The figures in this column were determined by difference, and are the total organic matter, moisture, and loss in the analyses.

The influence of the texture of the soil on the distribution of different truck crops is here also very apparent. Sample No. 1510, containing

2.80 per cent of clay and 6.24 per cent of silt, was taken from a field near Newbern adjoining that from which sample No. 1514 was obtained. This latter, it will be seen, has 13 per cent of clay and nearly 45 per cent of the three finest grades, viz, silt, fine silt, and clay. The first sample (No. 1510) is admirably adapted to the very early spring vegetables, such as potatoes, peas, tomatoes, sweet potatoes, melons, and asparagus. The heavier lands are adapted to the heavier and later truck, particularly cabbage, spinach, tomatoes, and peas. Crops planted at the same time on these two soils in the early spring would mature from six to ten days earlier on the light-textured soil than on the heavier soil. Samples Nos. 1524 and 1534, from Edenton and Hertford, are adapted to the very early spring vegetables. These soils are both too light in texture for cabbage. Sample No. 1522 represents the heavier soils at Edenton, well adapted to cabbage, although rather too heavy even for this crop. Sample No. 1566, from Elizabeth City, is well adapted to all truck crops. Sample No. 1519, from near the same place, would be classed as a very heavy truck soil, and adapted only to the later crops, except that, being adjacent to the water, it admits of planting a week or ten days earlier, and so matures its crop about the same time as lighter-textured soils further inland.

TRUCK SOILS OF VIRGINIA.

The accompanying table gives the mechanical analyses of some of the finest truck soils around Norfolk, Va. The two samples, Nos. 1595 and 1593, represent the finest type of truck land of that locality. They are adjacent to the water and the crops are thus insured against damage from late spring frosts.

TABLE 3.—*Mechanical analyses of subsoils.*

No.	Locality.	Organic matter, water, loss.	Gravel (2-1mm).	Coarse sand (1-.5mm).	Medium sand (.5-.25mm).	Fine sand (.25-.1mm).	Very fine sand (.1-.05mm).	Silt (.05-.01mm).	Fine silt (.01-.005mm).	Clay (.005-.0001mm).
	VIRGINIA.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1595	5 miles west of Norfolk.....	1.36	0.00	1.42	23.27	38.25	7.51	15.14	5.90	7.15
1593	4 miles west of Norfolk.....	1.26	0.00	0.64	24.04	41.03	5.71	11.54	7.33	8.40
1601	3 miles east of Norfolk......	4.15	0.00	0.27	42.12	12.96	6.63	20.20	4.79	8.88
1599	2½ miles east of Norfolk.....	2.20	0.00	2.67	25.17	5.12	10.16	31.45	8.88	14.35

These soils are both adapted to all of the early spring vegetables, but they are rather light in texture for cabbage and spinach. These crops will not stand the winter well on these light soils and have to be set out early in the spring. Sample No. 1599, from east of Norfolk, is very much heavier in texture than those just mentioned. This is a type of a large area of land in that locality admirably adapted to cabbage and spinach, and these are the staple crops. They are too heavy for sweet potatoes

and melons, and also for Irish potatoes. The Irish potatoes do well, but they mature nearly a week or ten days later than on the lighter soils west of Norfolk. The heavier soils are more valuable for cabbage for the reason that the plants can be put out in the fall and attain some growth during the fall and winter, and thus have an advantage over a crop which has to be planted on the lighter soils in the spring.

TRUCK SOILS OF MARYLAND.

An examination has been made of soils from a number of localities in the truck area of Maryland. This area is divided into the West Shore, or southern Maryland, and the Eastern Shore, by the Chesapeake Bay. The truck lands of southern Maryland occur principally in a narrow belt bordering the rivers and bay shore. The nearer the water the more valuable the land, both on account of the freedom from frosts and the cheapness of water transportation. The samples in this table are arranged according to the amount of clay in the subsoil. As thus arranged they are very nearly in the order of their relative agricultural value. The lighter soils, that is, those containing the smallest amount of clay, are considered the earliest and best adapted for the spring vegetables. The lands containing more than 6 or 7 per cent of clay are better adapted to cabbage, small fruits, and the later and heavier truck crops. The exception to this is where the heavier lands, as is the case with No. 573, for example, are situated directly on a point of land nearly surrounded by water, which insures them against spring frosts and enables the crops to be planted a week or two earlier than would be safe further inland.

To show the effect of texture on the adaptation of these lands to the different crops, two samples from Tick Neck may be cited. No. 585 represents the lightest grade of sandy land of that locality, adapted to the early spring vegetables, while No. 587, with the same exposure and separated only by a short distance, is much later and adapted to the heavier crops because it contains more clay and is more retentive of moisture.

TABLE 4.—*Mechanical analyses of subsoils of truck lands.*

No.	Locality.	Organic matter, water, loss.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	MARYLAND (WEST SHORE).	P. ct.	P. ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	P. ct.
815	Severn River	3.36	0.63	3.73	38.01	28.69	10.31	10.26	1.81	3.20
.....	Near Baltimore	8.21	[1]4.03	20.88	41.11	14.25	3.58	2.64	1.61	3.69
209	Cove Point	0.04	0.51	1.32	17.84	55.82	16.75	3.08	0.90	3.74
471	Marley post-office	0.16	0.28	5.42	41.45	26.73	12.46	7.22	2.21	4.07
472	.....do	0.30	0.49	4.96	40.19	27.59	12.10	7.74	2.23	4.40
561	Armiger	0.30	0.74	7.13	36.21	22.82	14.15	9.26	4.68	4.71

[1] Including 2.11 per cent larger than 2mm.

TABLE 4.—*Mechanical analyses of subsoils of truck lands*—Continued.

No.	Locality.	Organic matter, water, loss.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	MARYLAND (WEST SHORE)—con'd.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
585	Tick Neck, sandy land	0.24	0.45	10.33	46.29	20.15	8.17	7.11	2.29	4.77
583	1½ miles northeast of Marley	0.55	0.28	6.09	39.48	23.00	14.69	8.46	2.48	5.01
591	1 mile north of Marley	1.05	0.39	5.52	36.53	24.91	11.79	9.89	4.51	5.41
563	Armiger	0.31	0.39	7.04	37.51	21.45	13.45	10.72	3.72	5.41
469	Glenburnie	0.25	3.47	12.05	44.06	18.02	9.59	5.73	1.37	5.46
565	2 miles west of Armiger	0.59	2.12	8.81	31.35	22.82	16.76	10.19	2.08	5.47
1616	Washington, D. C	3.70	1.27	4.53	35.19	21.47	9.19	15.24	4.05	5.81
579	Rock Point	1.00	0.09	2.31	31.18	25.49	16.92	12.86	3.82	6.33
567	1 mile west of Armiger	1.09	2.46	13.32	39.83	14.14	9.34	10.17	3.29	6.36
589½	Marley Neck	6.04	0.97	6.22	29.96	21.91	11.57	12.80	4.08	6.45
473	.....do	0.38	0.44	6.46	36.73	19.51	10.28	13.42	5.61	7.14
270	South River Neck	0.54	0.32	5.81	40.63	28.93	9.44	4.60	2.04	7.63
587	Tick Neck, loam	3.18	6.06	22.09	29.87	9.82	6.52	10.71	3.86	7.89
145	Patuxent River	1.44	1.78	7.63	38.35	21.80	6.87	11.73	2.48	7.92
577	Magothy Neck	0.97	1.52	4.50	29.88	23.77	10.36	17.16	3.83	8.01
589	2 miles north of Armiger	......	2.33	26.08	33.06	10.18	4.71	13.14	3.58	8.29
575	Magothy Neck, loam	0.08	1.26	8.91	47.84	6.29	6.29	15.08	5.76	8.33
571	.....do	1.14	0.34	2.97	21.18	18.19	17.17	21.05	9.57	8.39
569	Magothy Neck	0.90	0.87	5.82	26.22	17.55	16.34	16.33	7.45	8.52
268	South River	2.48	0.04	1.97	28.64	39.68	11.43	4.95	2.02	8.79
590	2 miles north of McCubbins' Rock Point	0.44	0.91	5.45	28.73	22.81	13.44	14.77	4.29	9.16
581	½ mile north of McCubbins' Rock Point	0.71	0.56	4.83	27.49	16.36	12.51	22.39	5.03	10.12
467	Shipley	1.87	0.76	8.55	35.04	19.26	8.42	11.38	4.13	10.59
476	Furnace Branch	3.52	[1]2.80	8.36	20.11	10.72	10.15	17.98	8.76	11.60
573	Magothy Neck, "gravelly loam"	1.55	3.67	11.92	29.99	6.35	5.56	9.91	6.21	12.84

[1] Including 1.08 per cent larger than 2mm.

The Eastern Shore of Maryland, included in the peninsula district, has been a noted center of truck farming. The crops mature after the bulk of the Virginia crop has been marketed.

TABLE 5.—*Mechanical analyses of truck subsoils.*

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	MARYLAND (EASTERN SHORE).	*P. ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
1190	1 mile east of Barren Creek Springs	0.22	1.04	0.81	9.60	53.85	25.93	2.77	2.01	0.94	1.46
1209	Salisbury	0.14	0.91	0.85	6.29	38.11	56.66	9.77	4.53	0.94	1.76
1198	2 miles west of Barren Creek Springs	0.22	0.87	0.48	6.71	48.39	30.27	2.79	4.62	1.21	2.06

TABLE 5.—*Mechanical analyses of truck subsoils*—Continued.

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	MARYLAND (EASTERN SHORE)—continued.										
		P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
1213	1 mile southeast of Salisbury	0.33	0.50	1.91	6.43	32.95	33.69	10.22	9.15	2.08	2.60
1192	2 miles south of Barren Creek Springs	0.19	0.85	0.82	6.64	45.21	29.30	3.37	9.38	1.96	2.87
1223	Concord	0.44	2.02	0.99	6.94	33.29	31.36	9.05	10.24	2.81	2.97
1188	½ mile south of Barren Creek Springs	0.01	0.75	0.32	8.75	46.37	32.44	3.45	3.01	0.78	2.99
1234	New Market	0.23	1.29	0.50	6.47	31.07	15.80	7.40	26.73	4.26	3.50
1207	2 miles west of Salisbury	0.26	0.85	2.03	7.93	38.36	25.55	9.77	7.40	3.33	4.02
1240	6 miles south of Preston	0.32	1.52	5.78	17.54	37.23	17.04	5.71	8.40	2.16	4.04
1238	Cabin Creek	0.47	1.65	4.61	15.31	35.66	18.36	4.76	10.62	3.63	4.22
1219	American Corners	0.20	1.07	4.32	12.95	39.36	17.49	7.09	10.56	1.98	4.54
1232	1 mile west of New Market	0.42	1.70	0.72	6.41	31.93	16.70	11.94	15.82	7.51	4.81
1228	3 miles west of New Market	0.42	1.10	2.77	12.02	34.53	24.30	7.21	9.45	2.24	5.33
1225	Beulah	0.61	2.25	1.06	8.39	21.87	12.73	12.88	27.81	7.05	5.35
1230	2½ miles northwest of New Market	0.47	1.43	0.89	6.92	27.64	20.48	10.98	22.04	3.28	5.60
1215	3½ miles southeast of Salisbury	0.25	1.39	1.36	6.02	28.52	27.95	11.77	9.10	3.00	5.61
1217	6 miles southeast of Salisbury	1.29	2.84	1.15	6.99	33.52	17.85	13.19	12.21	2.86	7.15
1297	Mount Holly	0.75	1.65	2.21	8.40	23.07	14.03	13.54	24.54	4.41	7.53
1186	Linkwood	0.85	1.98	0.52	6.11	28.43	18.34	9.49	21.97	4.03	7.84
1236	New Market	1.15	2.07	0.37	6.35	24.27	13.12	11.16	22.94	2.95	9.43
1299	Mount Holly	0.92	2.03	0.69	5.97	22.91	14.68	12.17	25.19	3.98	11.19

The same marked effect of the texture of the soil on the distribution of the different classes of crops is shown in the investigations of the soils of this locality. Without considering the influence of the proximity of large bodies of water, the lighter soils, that is, those containing the least amount of clay, are invariably regarded as the earlier, and as a rule the crops mature from six to eight or ten days earlier than on the heavier truck soils. Salisbury is one of the principal centers of the trucking interest, and it will be seen that the soils around this place are very light textured and well adapted to the early spring vegetables. Barren Creek Springs is another locality where the soils are well adapted to early truck, but the industry has not yet been developed there as fully as at Salisbury.

A number of samples in this table were taken from Caroline County, where wheat is still grown on nearly all the farms, as it was grown throughout the present truck area until the peculiar adaptation of

these lands to truck farming and the improved facilities for transportation induced the farmers to abandon wheat and take up this much more profitable industry. These samples show that the soils of Caroline County which have been examined are well adapted to early truck, and nearly all of the county would be greatly benefited if the farmers would abandon wheat and turn their attention to this special line of farming.

The accompanying table gives the mechanical analyses of a number of samples from one of the most famous centers of truck farming in the country, namely, that portion of Long Island adjacent to New York City.

TABLE 6.—*Mechanical analyses of subsoils of truck lands.*

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	NEW YORK.	*P. ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
616	1 mile south of Jamaica...	1.08	1.40	9.09	21.46	35.75	16.05	6.18	5.24	1.35	3.29
558	1 mile south of Jamaica...	0.10	1.52	18.44	28.77	28.86	7.98	3.95	5.50	1.39	3.37
55	1½ miles east of New Lots.	0.22	3.78	6.15	18.35	34.57	14.18	7.49	9.13	1.87	4.13
532	Babylon	0.12	2.74	4.81	13.62	31.58	10.19	7.76	18.51	3.29	6.70
539	Jamaica	0.14	2.25	9.59	19.06	24.91	9.65	10.08	14.10	3.29	7.25
18	Flatlands.................	1.30	5.80	8.69	10.86	20.01	6.49	12.15	23.85	5.99	7.56
31	½ mile east of New Lots ..	0.62	1.88	11.80	22.20	25.53	8.70	7.32	12.63	2.32	7.72
56	1½ miles east of New Lots.	0.81	2.33	4.61	15.59	31.82	12.94	10.95	6.82	3.35	8.58
43	1 mile east of New Lots ..	0.84	2.50	12.94	11.52	28.08	12.00	10.72	10.48	2.63	8.60
23	New Lots..................	1.06	3.32	6.46	13.24	19.14	8.46	17.20	21.57	3.60	11.30
20	1 mile west of Flatlands ..	1.24	4.66	1.11	3.91	5.98	4.76	13.15	40.15	12.10	12.86

It will be seen that these soils have the same texture as the samples which have already been given from the Southern coast. The influence of the texture of the soil on the distribution of the different classes of truck crops is very marked here also. The lighter-textured soils are adapted to the early spring vegetables, while the heavier soils are better adapted to the heavier crops, such as cabbage and spinach, and to small fruits. For example, it is said that spring-planted crops can be forced to mature about two weeks earlier on soils represented by samples Nos. 616 and 558 than on the heavier soil, No. 539, the exposure and other conditions being nearly identical in the two places.

The accompanying table gives the mechanical analyses of early truck soils from Providence, R. I., and from Boston, Mass.

TABLE 7.—*Mechanical analyses of subsoils.*

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt .01–.005mm).	Clay (.005–.0001mm).
	MASSACHUSETTS.	P. ct.	P. ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	P. ct.
187	Boston	0.62	2.50	1.64	3.42	10.58	29.32	43.93	4.99	1.03	1.84
508	.....do	1.07	3.58	0.85	3.56	15.25	30.07	29.31	12.02	1.52	2.64
95	.....do	......	5.94	1.53	6.45	16.06	19.95	22.18	13.57	2.40	7.45
	RHODE ISLAND.										
523	Providence[1]	0.20	1.02	10.70	15.20	27.78	31.07	10.24	2.86	0.53	1.14
516	.....do	0.99	5.94	7.35	11.02	23.17	24.52	17.45	4.79	1.88	1.62

[1] Gravel larger than 2mm 21.21
Fine earth 78.79

100.00

The early truck farming of the Atlantic Seaboard is confined to soils similar in texture to those whose analyses have been given. The climate of course has much to do with the actual time of harvest in each locality, but the character of the soils and the proximity to large bodies of water determine the distribution of crops in each locality, and soils and transportation facilities together define the area over which truck farming can be profitably carried on in any locality.

TOBACCO SOILS OF CONNECTICUT AND PENNSYLVANIA.

Tobacco is grouped commercially into classes, types, and grades. The class represents the use to which it is adapted, whether for cigar, cigarette, smoking, chewing, or export trade. The type is dependent upon certain qualities, such as the color, texture, and flavor of the leaf, and upon the question whether it is sun-cured, air-cured, flue-cured, etc. The grade refers to the degree of excellence of the leaves from the same type or even from the same stalk. The different grades are designated as low, medium, and good, and also with respect to the use, as fillers, binders, wrappers, and the like.

Different types of tobacco are required for cigars, cigarettes, smoking, and chewing, and different grades for the wrappers and fillers of cigars and for plug tobacco. Furthermore, different sections of our own country and several of the importing foreign countries require different classes, types, and grades of tobacco for their use.

The English, German, and Italian markets require a coarse, dark, heavy type of tobacco, grown extensively in the Clarksville district of

Tennessee and Kentucky. The Austrian and Swiss markets require a lighter-colored and more leafy tobacco, which is grown upon the lighter and poorer soils of the Clarksville district. The French market requires a still lighter and coarser leaf. Nearly all of the Maryland tobacco and much of the Virginia and Ohio tobaccos go to France, Holland, and Germany for pipe smoking, as it is a mild, sweet-flavored tobacco, with free burning qualities, making it specially suitable for this use. The cigarette tobacco comes principally from the bright-tobacco soils of Virginia, North and South Carolina, and eastern Tennessee.

Tobacco can be grown on almost any well-drained soil which will produce Indian corn; but the climatic conditions and the texture and physical properties of the soil so greatly modify the development of the plant as to determine the distribution of the different classes and types. Climatic conditions control, of course, the general distribution, but the influence of the texture of the soil in modifying the effect of these climatic conditions determines the local distribution of types. Tobacco readily adapts itself to a wide range of climatic conditions, as is seen in the distribution of the plant in our own country from Florida to Wisconsin. While it adapts itself very readily to the different conditions of temperature and rainfall which normally prevail during the growing season throughout this wide range of territory, seasons which are either too wet or too dry very often reduce the yield per acre and impair the quality and the value of the product. The plant is, furthermore, peculiarly sensitive to the conditions of moisture and heat, resulting under existing climatic conditions from the texture and physical properties of the different soil formations, and this largely determines the local distribution of the different types of tobacco.

ADAPTATION OF SOILS TO VARIETIES OF TOBACCO.

Soils adapted to the production of the coarse shipping tobacco, suitable for the English and German markets, will not produce fine tobacco of any variety. Soils containing a large proportion of clay, or which otherwise are very retentive of moisture, produce large, heavy plants, which cure dark-brown or red, with large quantities of oil or gum in the leaves. Light, sandy soils, on the other hand, produce a thinner leaf, which cures a very bright red, mahogany, and even lemon yellow. So marked is this influence of soil upon the quality of tobacco that a fine bright-tobacco land may be separated by only a few feet from a heavier clay soil which will produce only a coarse, heavy shipping leaf. Varieties which produce an excellent quality of tobacco on soils to which they are adapted produce an entirely different type when planted on lands of a different character, and frequently fail entirely. Yellow Pryor and Orinoco grown upon rich lowlands, especially if well manured, produce a strong, heavy type of tobacco, while upon light, new land the product of the same varieties is yellow, fine flavored, thin textured, and sweet.

Manures and fertilizers tend to increase the yield per acre, but in the case of the fine, bright tobaccos this is usually accompanied by a deterioration of the quality of the product, especially if excessive quantities of stable manure and other forms of nitrogenous manures are added to the land. With the heavier varieties of tobacco, however, this increase of yield is often accompanied by a marked improvement in the quality of the product, as it becomes richer and contains more oil and gum, which is an advantage for the purpose to which this class of tobacco is adapted.

The distribution of the principal types of tobacco may be broadly stated as follows: The seed-leaf, or Havana, tobacco is produced in such quantities and such excellence as to give a distinct character to localities in Massachusetts, Connecticut, New York, Pennsylvania, Ohio, Illinois, Wisconsin, and Florida; the red shipping leaf gives a distinct character to localities in Virginia, Kentucky, Indiana, Tennessee, Iowa, and Arkansas; the white Burley gives a distinct character to localities in Ohio and Kentucky; heavy shipping tobacco for export gives a distinct character to localities in Maryland, Virginia, West Virginia, Kentucky, and Tennessee; mahogany and yellow wrappers and smokers give a distinct character to localities in Virginia, North and South Carolina, and eastern Tennessee.

The best soils for these different classes and types of tobacco are very different, ranging from the light, sandy lands of the pine barrens for the fine yellow varieties to the heavy clay soils of the limestone areas for the heavier grades of tobacco. This must always be borne in mind, as otherwise there would be apparent contradictions, since in some districts light, sandy loams, and in others strong clay soils, are described as best adapted to the variety of tobacco which gives character to the locality.

The writer has endeavored to study during the past season the conditions maintained by the soils adapted to some of these different classes and types of tobacco for the purpose of determining those which are essential to the best development of each of these types. This information, with a knowledge of the ordinary climatic conditions, would give a basis for the classification of tobacco soils and for the improvement and modification of the conditions in many soils which are not, under present methods of manuring and cultivation, well adapted to any particular type of tobacco. This work involves considerable preliminary examination of the physical conditions of the soils in the localities which are to be selected, and then the establishment of observing stations in these different areas. It has been impossible, for various reasons, to obtain in one year records of the soil conditions from many localities and, with respect to the localities from which we have obtained records, the data are not yet all available, and will not be until the tobacco is cured.

TOBACCO SOILS OF THE CONNECTICUT VALLEY.

The influence of soil upon the quality of the tobacco grown in the Connecticut Valley is very marked. Where the soil is a heavy clay loam, or for other reasons is normally very moist, the tobacco produces a thick leaf which has considerable oil and gum in its tissues, cures a dark color, and will bear sweating well, but is not well suited for cigar wrappers at present because light-colored, thin-textured wrappers are in demand at this time. Upon light, sandy soils the quality is very fine, the texture of the leaf is thin, and the color is light. It is this type of tobacco which is at present in demand for cigar wrappers. A good wrapper for our domestic use at present requires a leaf of fine texture and small veins, but with plenty of body. It must have elasticity and strength to make it pliable in working, and it must have good sweating qualities to bring out the flavor and to give it the aroma it needs when finally cured.

Samples of the soils and subsoils have been collected from a number of localities representing some of the principal types of land adapted to tobacco and several soils not adapted to this crop. Observations have been taken every day during the growing season to determine the amount of moisture in the soils in several places.

The accompanying table gives the mechanical analyses of three of the very finest types of tobacco soil in the State of Connecticut for the light-colored, thin-textured wrappers.

TABLE 8.—*Mechanical analyses of subsoils of tobacco land.*

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	CONNECTICUT.										
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
842	3½ miles east of East Hartford, "plains"	0.46	2.08	1.05	5.03	18.31	25.83	32.11	11.31	1.15	2.51
1251	Poquonock	0.56	1.64	3.22	7.53	19.64	23.76	34.50	5.92	0.78	2.53
729	East Hartford, Podunk district	0.49	2.05	0.09	0.30	1.11	9.95	52.47	27.73	3.56	4.00

The amount of clay in these samples ranges from 2.5 to 4 per cent. The soil of the "plains," near East Hartford, is a very light, sandy soil, which grows a tobacco of a very fine texture and very good color, but the yield per acre is naturally low. The conditions which give this land its characteristic value are undoubtedly to be found in the small content of clay and in the small amount of moisture which these "plains" soils maintain. No observations have been made on the moisture condition of these soils in their natural condition in the field.

The subsoil of the Poquonock lands is seen to contain about 2.53 per cent of clay, 5.92 per cent of silt, and less than 1 per cent of fine silt.

These soils have almost identically the same texture as the "plains" soil, and the development, texture, and color of the tobacco crop is believed to be about the same. The yield is larger in this particular locality, because the lands have been more intelligently cultivated. This is believed to represent the finest type of land of the Connecticut Valley for the light-colored, thin-textured cigar wrapper, which approaches the Sumatra grade. When heavy, dark wrappers are in style this soil can not compete with the heavy limestone soils of Pennsylvania for the domestic market.

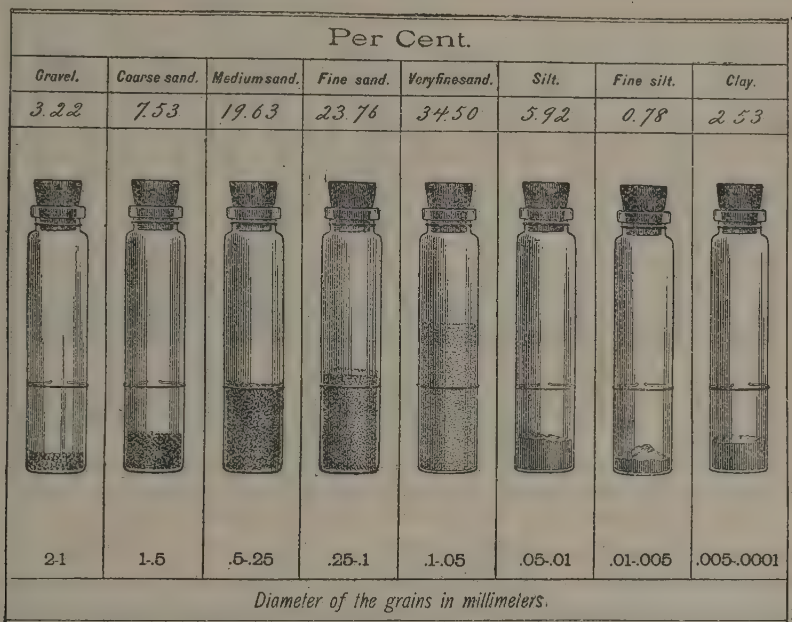

FIG. 4.—Mechanical separation of the gravel, sand, silt, and clay in 20 grams of subsoil from Poquonock, Conn., adapted to tobacco.

The amount of moisture has been determined in these soils throughout the growing season. The results are shown in a diagram, figure 6, page 149. The figures on the left-hand side of the diagram indicate the percentage of moisture found in the soil to a depth of 12 inches from the surface. The dotted portions of the line pass through the dates where observations are missing.

The soils of the Podunk region of East Hartford and Windsor, represented by No. 729, are seen to have about 4 per cent of clay and 27.73 per cent of silt, with 3.56 per cent of fine silt. The relatively large amount of silt makes these soils more retentive of moisture than the soils of Poquonock, and they are said to grow a rather heavier type of tobacco. The relative character of the crops of these two soils during the past season can not be exactly determined until the crops come out of the sweat and are finally cured, which requires nearly a year from the time the crop is harvested.

It will be seen that the soil of the Podunk district contained during the season considerably more moisture than the soil at Poquonock, and this undoubtedly accounts for the heavier and darker type of tobacco produced.

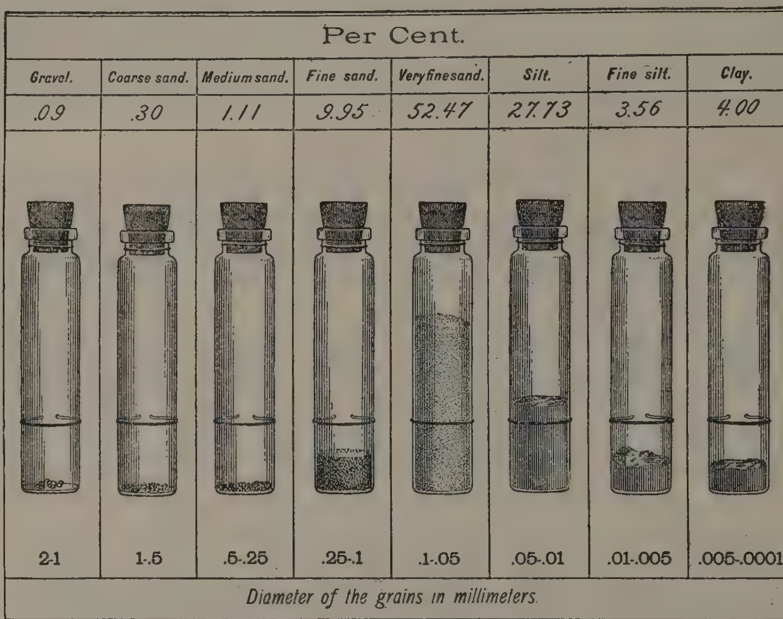

FIG. 5.—Mechanical separation of the gravel, sand, silt, and clay in 20 grams of subsoil of the Podunk district, East Hartford, Conn., adapted to tobacco.

Hatfield, Mass., is another center for the tobacco industry of the Connecticut Valley, and samples have been collected from a number of localities in that vicinity. Their mechanical analyses are given in the accompanying table.

TABLE 9.—*Mechanical analyses of subsoils.*

No.	Locality.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1mm).	Coarse sand (1–.5mm).	Medium sand (.5–.25mm).	Fine sand (.25–.1mm).	Very fine sand (.1–.05mm).	Silt (.05–.01mm).	Fine silt (.01–.005mm).	Clay (.005–.0001mm).
	MASSACHUSETTS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1039	Hatfield, "2-acre lot"	0.21	1.48	0.00	0.00	2.50	28.11	55.78	10.71	0.63	0.92
1173	Hatfield, representing average soils of this locality	0.59	2.71	0.00	0.00	0.40	9.00	42.12	38.90	3.07	3.17
875	Hatfield, 100 feet from Connecticut River	0.66	2.15	0.00	0.00	0.12	2.31	40.30	45.41	4.15	4.50
901	Hatfield, 200 feet from Connecticut River	0.82	2.90	0.00	0.00	0.21	2.13	38.11	45.09	4.76	5.98
	Not suited to tobacco.										
999	Hatfield, "heavy loam"	0.88	3.45	0.00	0.00	0.10	0.43	21.88	67.00	3.41	2.61
1250	Hatfield, "meadow land"	0.10	4.75	0.00	0.00	0.05	0.50	32.64	49.32	5.46	6.79

There are two very different types of land represented here. Sample No. 1039 came from a 2-acre lot in the town of Hatfield, considered to be of the very finest type of tobacco land of the locality. The yield per acre is small, but the color, texture, and quality of the tobacco are very superior, and the wrappers bring a high price. It will be seen that the texture of this soil is similar to that of the Poquonock and of

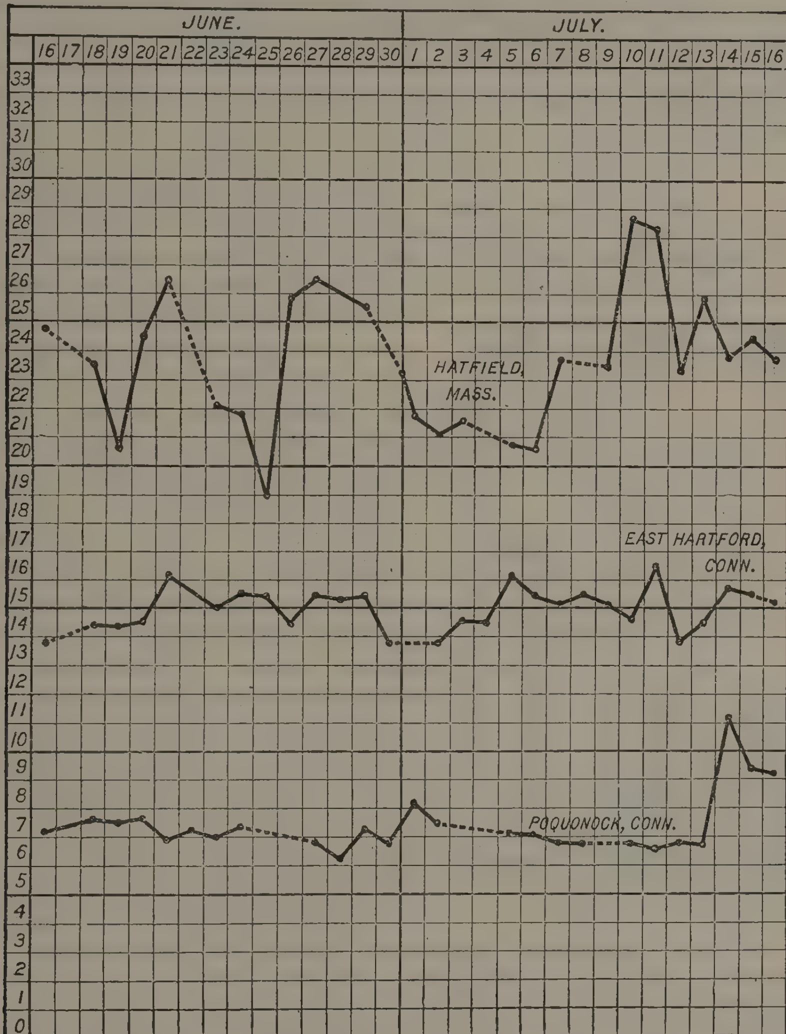

FIG. 6.—Curves showing the amount of moisture in the tobacco soils at Poquonock, East Hartford, and Hatfield, in the Connecticut Valley.

the "plains" soil at East Hartford. Sample No. 1173 represents about the average tobacco soils of the Hatfield district. This is said to produce a very fine quality of tobacco. It will be seen from the analysis that the texture of this soil is quite similar to that of the Podunk district of Connecticut. Samples Nos. 875 and 901 represent what are

called the "river sands," near the edge of the first terrace overlooking the river. They have a small percentage of clay, but a rather large amount of silt. This might make them rather too retentive of moisture, but their position on the bank of the river insures perfect drainage, as the bluff is 25 or 30 feet high at this place. For this reason these soils produce a very fine quality of tobacco, as fine in every way as does No. 1039. The importance of the bluff in securing thorough drainage to these lands is very marked. Sample No. 875 is taken about 100 feet nearer the river bank than No. 901, and the soil is considered more valuable for tobacco than the other, the product being brighter and of a finer texture.

The other two samples were taken from different types of land. Sample No. 999 represents what is locally known as a "heavy loam" and No. 1250 is from a meadow land. These two soils are said to produce tobacco the leaves of which are coarse textured and oily, do not take on a good color, and are unsuited to the present market demands; but when dark wrappers are in style these lands will be taken up and the cultivation of tobacco will be abandoned on the light soils. These soils do not differ materially from the other samples at Hatfield except in the large amount of silt they contain. Owing to this large amount of silt and to the peculiar arrangement of the silt grains, these soils are very close and very retentive of moisture, and to these soil peculiarities are due the characteristics which unfit this tobacco for the present demand. The plants show all the symptoms of an excessive growth from an excessive water supply.

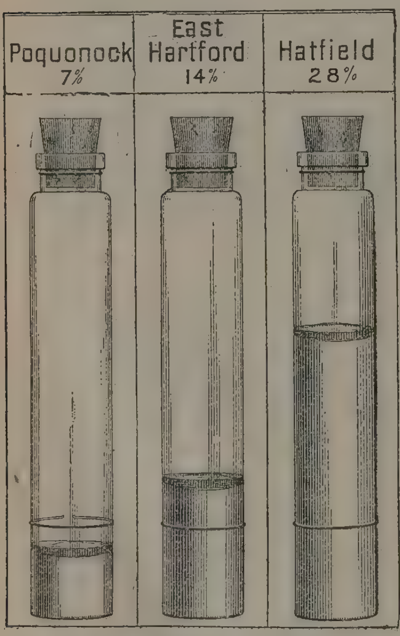

Fig. 7.—Average amount of water maintained in 20 grams of tobacco soils at Poquonock, East Hartford, and Hatfield, in the Connecticut Valley.

The accompanying diagram (fig. 6) shows the amount of moisture maintained during a part of June and July in the soils at Poquonock, where the light wrappers are produced, in the soils of the Podunk district, and in this "heavy loam" soil at Hatfield (No. 999), which is unsuited to tobacco.

Figure 7 shows the actual amount of water maintained, on the average, by 20 grams of the soil at Poquonock, and at East Hartford, and of this heavy loam at Hatfield, through the season. The excessive amount of moisture maintained by the Hatfield soil is strikingly apparent.

It may be asked if this "heavy loam" from Hatfield is better adapted to other types of tobacco. This is undoubtedly so, but just at present the heavy, coarse types of tobacco, which in its present condition it is adapted to grow, are worth but little. It may also be asked if the conditions could be modified so as to make the land better adapted to the finer types of cigar tobacco. This could undoubtedly be done. The first thing needed would be to underdrain the land by tile drains so as to remove as much as possible of the excess of water. The tobacco should be grown on high beds or ridges, which would keep the roots in drier soil and materially improve the texture and quality of the crop. The texture of the soil should be changed by judicious methods of cropping, manuring, and cultivation, making it more loamy and less retentive of moisture. The excessive growth of the plants could be checked by cultivation, or by the use of certain manures and chemicals which would prevent the plants from taking up so much moisture notwithstanding its abundance in the soil. But all this would be expensive, and it is a question whether it could be economically done under the prevailing conditions.

TOBACCO SOILS OF PENNSYLVANIA.

The characteristic tobacco of Pennsylvania is grown on the heavy limestone soils having a stiff red-clay subsoil. These soils represent the very finest type of agricultural land, being well adapted to both wheat and grass. They are identical in geological formation, texture, and agricultural value with the soils of the Cumberland Valley of western Maryland and Virginia and with the soils of the blue-grass region of Kentucky. There are, of course, many areas along the river, on the islands, and back in other of the geological formations of the hill country where sandy soils prevail and where a light-colored, thin-textured leaf is produced. This latter type of tobacco at present has a higher market value than the crop from the heavier soils, but the type which has given character to the tobacco area of Pennsylvania is that grown upon these rich and fertile limestone soils of Lancaster and the adjacent counties. These limestone soils produce a heavy, dark type of tobacco admirably adapted for wrappers for our domestic use when dark cigars happen to be in fashion.

The fad or fancy for light or dark cigars is difficult to explain. It causes prices to fluctuate first in favor of one and then of the other of our two principal domestic types of tobacco.

These conditions should be fully realized by the tobacco planters so that they can adapt themselves to the market demands which they can not control. They should fully understand the important influence of the character of the soil on their crop. When the fashion calls for light cigars they should cultivate only their lighter soils and use their heavier lands for other crops. When dark cigars are in demand the lighter soils should be diverted from this use and the heavier soils be once more

taken up. The method of cultivation also should tend to emphasize as much as possible the differences in the conditions of these two classes of soils; the lighter soils should have perfect drainage and maintain but a small amount of moisture, while the heavier soils should maintain at all times an abundant and uniform supply of moisture.

The accompanying table gives the mechanical analyses of two subsoils of tobacco lands from the typical tobacco area of Lancaster County.

TABLE 10.—*Mechanical analyses of subsoils.*

No.	Locality.	Organic matter.	Gravel (2-1mm).	Coarse sand (1-.5mm).	Medium sand (.5-.25mm).	Fine sand (.25-.1mm).	Very fine sand (.1-.05mm).	Silt (.05-.01mm).	Fine silt (.01-.005mm).	Clay (.005-.0001mm).
	PENNSYLVANIA.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
1360	Marietta	4.36	0.12	0.22	0.27	0.37	7.48	28.28	16.24	35.80
16	Lititz	5.34	0.36	0.40	0.93	3.11	11.45	30.55	10.35	36.30

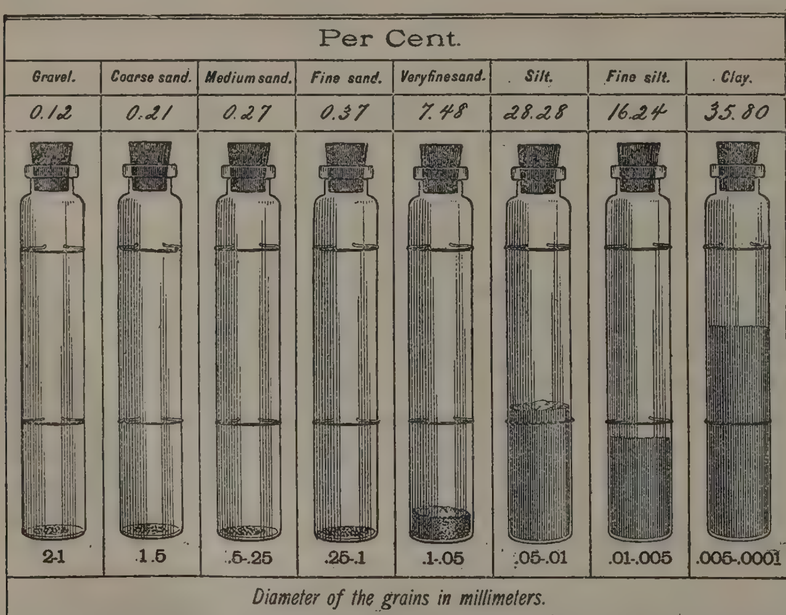

FIG. 8.—Mechanical separation of the gravel, sand, silt, and clay in 20 grams of subsoil from Marietta, Pa., adapted to tobacco.

It will be seen that these subsoils contain about 36 per cent of clay, nearly as much silt, and about half as much fine silt. They contain only a very small percentage of sand. There can hardly be a greater contrast in agricultural soils than between these heavy limestone soils adapted to grass, wheat, and the heavy types of tobacco, and the light sandy lands of the Connecticut Valley.

The accompanying diagram (fig. 9) shows the amount of moisture maintained during the month of July by the soil at Marietta, from determinations in samples taken in the field and sent in to the laboratory of the United States Department of Agriculture, compared with the moisture determinations at Poquonock and East Hartford, Conn., which have been given elsewhere.

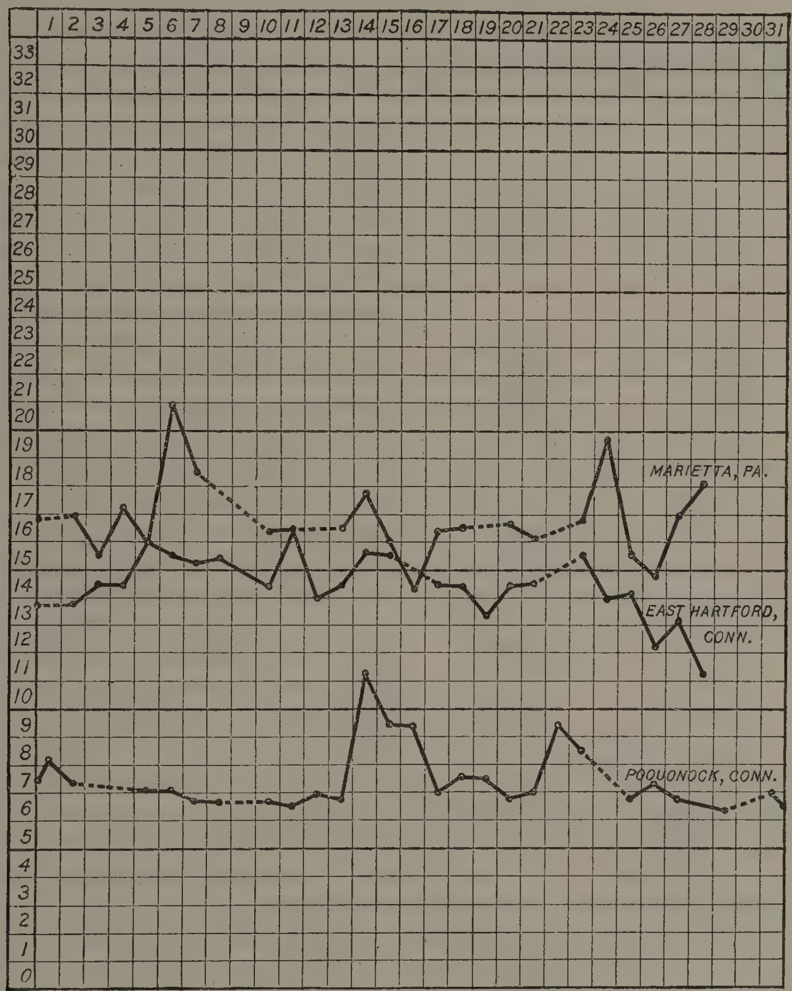

FIG. 9.—Curves showing the amount of moisture in tobacco soils at Poquonock and East Hartford, Conn., and Marietta, Pa.

It will be seen that the limestone soil at Marietta maintains nearly three times as much water for the plants as the light soil at Poquonock, and this more abundant water supply would be expected to have just the effect which is apparent in the darker, heavier type of tobacco produced.

The Connecticut Valley tobacco competes principally with the Sumatra, and the Pennsylvania with the Cuban tobacco. Our planters claim that the domestic wrappers from the Connecticut Valley have a better color and a better flavor than the Sumatra tobacco. The latter, however, has an exceedingly thin leaf, hardly thicker than tissue paper, but remarkably strong, elastic, and pliable. The veins are so delicate that they do not need to be removed. The leaves are so thin and yet so strong and cut to such advantage that manufacturers can estimate very closely how many cigars a pound of wrapper will cover. It is said to cover from four to seven times as many cigars as an equal weight of the domestic leaf. The cigars also have a smoother appearance and are thought to make a better appearance in the windows and show cases. For these reasons manufacturers have been paying from $3 to $5 per pound for the Sumatra wrapper rather than pay from 25 to 50 cents per pound for the domestic leaf. The problem before our planters, therefore, is to make a smaller and thinner leaf, with more elasticity and strength and with much smaller veins. The peculiar character of the Sumatra tobacco must be largely due to the climatic conditions of the island, but the same result can possibly be obtained here by close and intelligent attention to selection and breeding of varieties and by control of the soil conditions.

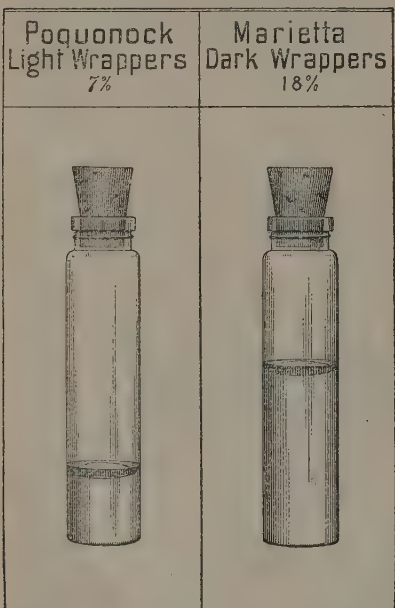

FIG. 10.—The average amount of water in 20 grams of tobacco soils of Poquonock and Marietta.

The Pennsylvania tobacco is well adapted for cigar wrappers, but it lacks the peculiar delicate flavor and aroma of the best grades of imported Havana. These qualities are undoubtedly due, in large part at least, to the tropical climatic conditions of the island. Whether these same qualities can be obtained in the same perfection under the existing climatic conditions in Pennsylvania, and if not, whether these conditions can be so controlled or changed as to give the desired qualities, can not be foretold, but offer a legitimate and promising subject for investigation. The improvement of the crop should be carried on in the lines indicated in this paper by comparing the conditions of climate, especially the conditions of moisture and temperature, within the range of the best tobacco soils of Cuba, with those conditions prevailing in Pennsylvania. When these are known they will form a basis,

otherwise wanting, for the intelligent control of the soil conditions or the improvement of methods of cultivation and treatment.

Tobacco is grown in Pennsylvania in rather small patches, the average size of the fields being about 3 acres. A small proportion of the farmers cultivate as much as 5 acres, but it is rather uncommon to have more than this, and there is a disadvantage in having more, as the crop can not be so well attended to. The crop is grown under a very intensive system of cultivation, involving great care, labor, and expense. With such small areas as these there is no good reason why planters should not insure their crop against injury by drought by having small irrigation plants which would render them in a measure independent in case of any deficiency in the rainfall. The water could be obtained either from springs or streams, of which there are a great many in that limestone area, or by pumping with a windmill or small farm engine. In the arid regions of Kansas a good windmill, it is claimed, will fill a reservoir large enough to irrigate as much as 5 or 10 acres of land, even where several applications of water have to be used during the growing season. In the tobacco area of Pennsylvania probably one thorough irrigation would carry a crop over the most prolonged drought which is there liable to occur. A reservoir 100 feet square would be sufficient to irrigate the crop, and this reservoir could be stocked with fish, which would prove a source of pleasure and profit. If it were kept constantly filled it could be drawn upon for the tobacco crop when needed, for the garden if it were conveniently located, and for other general farm purposes. The cost of such an outfit would be comparatively small; it could be made to pay by the amount of fish it would produce, if properly attended to, and as a measure of precaution and insurance against loss of the crop by drought it would be a wise investment even if it were used only once in two or three seasons.

Where there are no available springs or streams and a windmill can not well be used, a small farm engine, such as would run a thrashing machine, could be very economically employed. Such an engine attached to one of the many forms of irrigating pumps would irrigate the entire tobacco field in a day or two at a very inconsiderable cost for fuel, labor, and wear and tear of machinery. The advantage of this would be that with small driven or bored wells located on different parts of the farm the engine and pump could be moved from place to place as the different fields were cultivated in tobacco in rotation from season to season.

CONDITIONS IN SOILS OF THE ARID REGION.

The so-called arid portion of Kansas and Nebraska is, broadly speaking, that portion of the States lying west of the one hundredth meridian; between the one hundredth meridian and the ninety-seventh the climate is called semiarid; and east of the ninety-seventh is the humid portion of the States. The mean annual rainfall of the western or

arid portion is from 15 to 20 inches; of the central or semiarid portion, from 20 to 30 inches; and of the eastern or humid portion, 30 inches and over. There are of course no sharp lines separating these divissions, nor do the boundaries approach a north and south line, for the belts of greater or less precipitation have very sinuous courses.

It is generally conceded that 20 inches of well-distributed rainfall in Kansas will make an abundant crop of wheat or corn. That there must be some rather anomalous condition here is shown by the fact that in much of the humid portion of the eastern United States there has never been so little as 20 inches of annual rainfall within the period of reliable records, and in years of most disastrous drought the rainfall has been greater than this. The fact that a crop can be made in Kansas and Nebraska with such a small annual rainfall is particularly striking when it is remembered that, owing to the drier conditions of the atmosphere, evaporation is very much greater there than in the East.

There are localities in the West where the total annual rainfall does not exceed 6 or 8 inches. It does not seem possible that with this rainfall under ordinary circumstances crops could be produced by any system of agriculture, unless water were artificially supplied. However, it seems possible, outside of these exceptional cases, that with improved methods of cultivation the conditions actually existing can be so utilized as to secure reliable and satisfactory crops.

Statistics show that in the humid portion of the United States, having a mean annual rainfall of about 40 inches, 50 per cent flows off into the streams and is of no direct benefit to agriculture. This excess of rainfall reaches the streams partly by flowing over the surface of the ground and partly by slow percolation through the soil. Fifty per cent of the rainfall, or 20 inches per annum, evaporates directly from the surface of the soil or is transpired by plants.

Practically, therefore, there are about 20 inches of rainfall at the disposal of agricultural plants, and the highest art of cultivation consists in conserving this moisture, reducing that lost by evaporation from the surface soil to a minimum, and maintaining a sufficient amount at all times at the disposal of crops.

There is one factor which has a very important bearing upon the conditions in the humid as compared with those in the arid regions. In the humid region of the Eastern States the soil is continuously moist from the surface down to a depth at which it is completely saturated and from which water is constantly flowing out into wells, streams, and rivers. The water descends through the soil both by virtue of its own weight and by capillary force. According to capillary laws the water is pulled downward when the subsoil contains less water than the soil. Gravity and capillary force are both more effective in moving water through a moist subsoil than a dry one; hence there is danger in the East of the water being pulled down below the reach of plants in time of drought, while in the West, where the subsoil at the depth of a few feet is continuously dry, this could not happen.

Plants may be likened to a pump, which must have a steady and sufficient stream flowing into the well lest the surface of the water shall fall below the valve and the pump become inactive while there still remains a considerable amount of water in the well. There must be an adequate supply of water in the soil for the plants to draw upon, and this supply must be within their reach. To illustrate: A plant may wilt in a soil of close texture containing 10 or 12 per cent of moisture, because with so little water present in the soil the movement of water to the roots of the plant would be comparatively slow, and the volume supplied per minute or per day would be insufficient; the plant would quickly exhaust the supply in the immediate neighborhood of its roots, and the amount necessary for its continued growth could not be pulled up from the surrounding soil rapidly enough to make good the loss. In a soil of different texture the same plant may not suffer until the supply falls to 4 or 6 per cent.

ARID AND HUMID REGIONS COMPARED.

There must, therefore, be a certain minimum amount of moisture in all soils, just as there must be more water in a well than the pump will ever use. This minimum amount will depend upon the structure of the soil and the rate of movement of moisture and upon the requirements of the plant. An ordinary rainfall will have a far more beneficial effect upon the crop growing on a soil which contains this minimum amount than upon a crop growing on a soil containing less than the minimum. It must also be borne in mind, in comparing the soil conditions of the humid and arid regions, that the excess of moisture in the humid regions may often be of indirect value to agriculture by increasing the availability of the moisture which is to remain.

In the arid portions of Kansas, Nebraska, and Colorado, with a mean rainfall of nearly or quite 20 inches per annum, statistics of the gauging of rivers and streams show that 10 per cent, or 2 inches, of this rainfall flows off into streams and is of no direct benefit to agriculture. This gives, broadly speaking, 18 inches of rainfall available for agriculture in the arid regions as against 20 inches of available rainfall in the humid portion of the United States. Statistics show likewise that the greater portion of this rainfall in the arid region comes during the growing season. From April to the last of August they have an average rainfall of between 3 and 4 inches a month.

It appears at first sight a rather anomalous fact that there is nearly as much available rainfall in the arid as in the humid region; but there are several modifying circumstances that must be borne in mind. In the first place, the humidity of the atmosphere is very much less and evaporation is very much greater in the climate of the arid region. Statistics show that the annual evaporation from a free-water surface in the arid region is about 60 or 80 inches. In the humid portion of the United States the evaporation from a free-water surface is equal to

about 30 inches per annum. Roughly speaking, therefore, the amount of evaporation is twice as great in the arid region under consideration as in the humid portion of the country. Relatively more of the rainfall would therefore evaporate from the soil and relatively less would be available to plants. It would also seem that plants would transpire much more water and would require a more abundant water supply in the arid climate. It will be remembered, too, that there is practically no excess of water in the soils as in the soils of the humid region to make these 18 inches more available to plants.

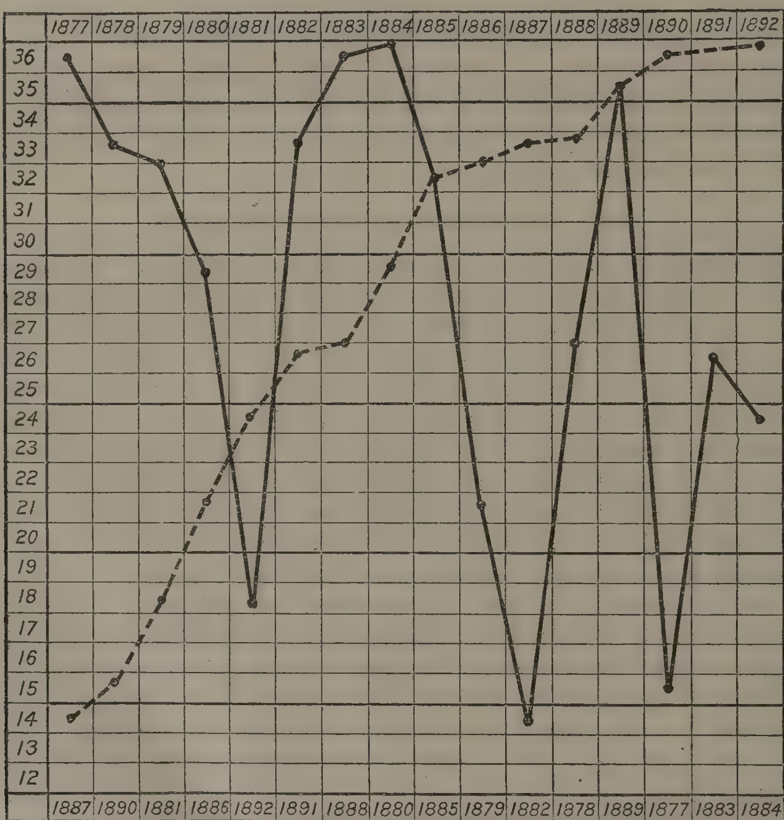

FIG. 11.—Average yield of corn in bushels per acre in Kansas, 16 years.

The fact remains, however, that in years of normal rainfall well distributed over the growing season, small though it is, a good crop is obtained throughout the semiarid region, and even on the so-called arid plains, where the land is properly cultivated. Statistics compiled by the Kansas board of agriculture show that in the sixteen years from 1877 to 1892, inclusive, the yield of corn per acre in the State of Kansas exceeded 30 bushels in eight seasons and the yield fell below 20 bushels per acre in three seasons. This is shown graphically in the accompanying illustration (fig. 11).

The average yield of wheat during this same period exceeded 15 bushels per acre during seven seasons and was under 11 bushels per acre five seasons. In the arid portion of the State a fairly good season occurs about two years in five, the remaining three out of the five seasons being too dry for a good crop. The fact that they can make a crop at all with an annual rainfall of 20 inches under the conditions which have already been considered is surprising, and indicates that there must be conditions which are not strictly comparable with those in the humid region, and that there are advantages to counteract the apparently unfavorable conditions.

DEPTH OF SOIL MOISTURE.

A considerable portion of the 2 inches of annual rainfall of the arid region which finds its way into streams and rivers must flow off over the surface and not even enter the soil. The extreme and rapid variation in the volume of the rivers, and the frequent torrential showers, during which the ground is flooded with water, indicate that this condition does in fact prevail to a large extent. Some water is retained by local depressions until it sinks, and there are undoubtedly soils of loose, light texture into which a considerable amount descends and finds its way to the rivers and streams by slow percolation; but as a rule there seems to be no connection between the surface moisture and the underlying "water table." The natural prairie sod sheds water like a roof when it is delivered rapidly and in large volume, and it is only with a long-continued, gentle rain that the soil and subsoil under the sod will absorb any considerable amount of moisture.

During a recent examination of the conditions in the soils of the plains of western Kansas, Nebraska, and eastern Colorado, no trace of moisture was found in a number of borings from just below the surface to a depth of 3 feet under the natural prairie sod, except on the light soils of the sand hills near Garden City and in a few depressions, where water had evidently been caught. The season had been exceptionally dry, but an inch of rain had fallen about a week before the examinations were made. Where the sod had been broken and the land had been under cultivation during the season the subsoil was quite moist, and more moist the more thorough the cultivation had been.

At Geneva, Nebr., the soil and subsoil immediately under the prairie sod was so dry that it was extremely difficult to take a sample with an auger, both because it was hard to bore into and because the material loosened by the auger was so dry and powdery that it ran off the auger like fine, dry dust or sand. In an oat field, which had been thoroughly prepared by subsoiling two years before, the subsoil was quite moist, although the ground had not been actually cultivated for a year. In an adjacent field which had been subsoiled the previous year, and during the present year had been thoroughly cultivated in nursery stock, the subsoil down to a depth of 3 feet was so moist that it could be

molded in the hand. These three localities were not over a few hundred feet apart and had been exposed to precisely the same rainfall, but had been subjected to these different methods of cultivation.

It is a common inquiry in the arid region after a rain, how far the moisture has descended, or, generally, how far it is down to dry soil. The evidence of well-diggers is that after passing through the upper few feet of earth the underlying material is dry until they approach the water-bearing layers of sand and gravel. The fact of the accumulation of alkalies shows that the subsoil is not continuously wet down to the "water table," as otherwise these would be leached out and carried off through the subsoil as they are formed.

Water descends very slowly and to a very limited extent in a perfectly dry soil, while it will spread out very rapidly in a soil which is already moist, but short of actual saturation. Water may fall for days upon a pile of dry manure and not wet the mass deeper than a few inches. Water may likewise fall upon a dry dust pile and not spread through the mass, but be contained near the surface, unless it continues to fall, in which case the whole mass of the dusty material may become saturated. Water does not readily spread through a previously dry soil, because the tension or contracting power of the surface of the water is greater than the attraction of the soil grains, which tends to cause its diffusion through the mass. One may see, therefore, a nearly saturated layer closely adjacent to a perfectly dry and dusty mass. On the other hand, if there is any appreciable amount of moisture in the soil the tension of the water surface will cause it to contract and pull water from above into the subsoil.

It would follow, therefore, that the moisture would not descend into the dry subsoil of the upland prairie until the successive depths had become so far saturated that they could no longer hold the water back, and it would pass downward very gradually into the lower depths saturating, or nearly saturating, each successive depth as it progressed. Unless the rainfall was so great and so continuous as to saturate the soil to a considerable depth, the water would not pass down to a great extent in the dry material. The whole supply of moisture absorbed by the soil would remain within a short distance of the surface, and when evaporation was started again from the surface or the moisture was used up by plants the water would be pulled up again from the depths to which it had progressed rather than proceed on its downward course. There is less force to pull it down into the dry subsoil than its own contracting power, which pulls it up through the moist soil to the plant or to the surface of the ground.

It appears probable, therefore, that in the more retentive soils of the arid regions the whole of the 20 inches of rainfall, or as much of this as is absorbed by the soil, will be held within a few feet of the surface, within easy reach of the roots of plants. The problem should be how to conserve the moisture, diminish the evaporation from the

soil, and maintain as much as possible of the supply for the use of crops.

Two things suggest themselves at once: The preparation of the soil must be sufficiently thorough and deep to insure the absorption of the whole amount of the rainfall, and preparation should be so thorough and deep that this water will be carried to a sufficient depth to diminish the chances of surface evaporation and prevent the saturation of the upper soil, which would be prejudicial to plant growth. The water must be absorbed as deeply as possible, so as to check surface evaporation, and at the same time be maintained sufficiently near the surface to be available to plants as needed. Where water is of so much value and of such vital importance, not a drop of rainfall should be allowed to waste by flowing off over the surface. It should all be absorbed by the soil. The rains are often so torrential in character that the soil must be in a condition to absorb the water very rapidly to prevent any loss.

The conditions actually existing in these soils should be made the subject of careful and thorough investigation. The amount of moisture actually maintained by the soils should be ascertained by daily determinations, to give a basis for working out improved methods of cultivation or planting for the conservation of moisture. The rainfall should be followed and its whole history worked out from the time it enters the soil. In the first place, how deep does the rainfall penetrate into the different soils of the plains? This could be ascertained at different depths at intervals of a week or ten days throughout the season by moisture determinations. Is any of the rainfall drawn so low as to be unavailable to plants and lost by percolation into the "water table"? How much of the rainfall evaporates from the different types of soils, how rapid is this evaporation, and how even are the conditions which the principal soils maintain? What part of the moisture evaporates from the soil and what part is transpired by the growing crop? How much water does a plant transpire in the arid regions for every pound of dry matter produced as compared with the same class of crops in the humid regions? These are all fundamental questions, which will have to be understood in order to secure any intelligent improvement of the methods of cultivation and cropping.

More than half of the annual precipitation in Kansas occurs in the four crop-growing months of April, May, June, and July. During May and June especially the frequent showers induce a very rank and luxuriant growth, and there is nearly always up to the middle or end of June the prospect of a large corn crop. It is not uncommon, however, for a dry spell in July to reduce the promised yield by 100,000,000 or 150,000,000 bushels. These dry spells last from two to four weeks, frequently resulting in great damage to the corn crop.

Wheat is usually harvested before this midsummer drought comes on, and there is less variation in the yield of wheat in the State than in

the corn crop. Such crops also as turnips, millet, and sorghum do very well from the August rains. The drought comes frequently at the most critical time of all in the development of the corn plant—just as it is tasseling out. It should be possible to breed new varieties, maturing earlier or later, so as to secure a crop at a different stage of development during this usual summer drought.

HOT WINDS.

The very time when the crop is suffering from drought is the time of all others when hot winds are liable to occur. These winds blow at the rate of 20 to 30 miles per hour, the temperature of the air frequently ranging from 100° to 106°, with only 20 to 30 per cent of relative humidity. This vast body of dry, hot air passing over the crop induces such rapid evaporation that the roots can not possibly supply sufficient moisture, and the plants are completely desiccated, or dried out. The cells dry up to such an extent that they die, and the whole leaf structure collapses and hangs limp and lifeless. The effect of hot winds upon the crop is markedly different from the effect of drought alone. In an ordinary drought the fodder dries and is cured much as if it had been cut and exposed to the sun and air, the plants, however, remaining erect. The effect of hot winds is much more quickly fatal to the crop; two or three days is often sufficient to destroy the most promising field of corn. The evaporation from the plants under these conditions must be enormous. It is so excessive, indeed, that even with the soil quite moist the powers of the plant may be taxed beyond endurance.

There are several possible ways to prevent or greatly lessen the injury from hot winds. Wind-breaks diminish the injurious effects of hot winds, for when the air is quiet the evaporation from the leaves increases the humidity of the air immediately around them, and this diminishes the evaporation from the leaf. If this air is removed, however, and quantities of dry air are rapidly presented to the plant the excessive evaporation is continued. Anything, therefore, which will retard the rate of movement of the wind will tend to diminish evaporation from the plants within the area of its influence. The more moist the soil can be kept through methods of cultivation the less damage there will be to vegetation, for the roots will have a larger supply of moisture to draw from. The hot winds rarely do much damage over irrigated fields when the water supply can be properly controlled. The most disastrous effect of hot winds, however, frequently follow a rainfall occurring after a long period of drought. During the rain transpiration from the plant is checked and the cells become excessively turgid and possibly weakened through distention and possibly by the presence of organic acids. When the hot winds immediately follow this abnormal condition of the plant, the evaporation is rapidly increased, the cells lose their water and collapse and die, as possibly they would not have done if the conditions preceding the hot winds had been more normal.

BENEFIT OF UNDERSTANDING SOIL CONDITIONS.

It may be asked what advantage it would be to understand soil conditions and what control of them is possible. As regards the first question, this knowledge will make it possible intelligently to classify the soils according to the conditions which they maintain and predict what classes of crops they will prove adapted to grow. It would suggest also the way in which the soil conditions should be changed to make them correspond still more closely to the requirements of the class of crops to which they are most nearly adapted. As regards the second question, it is quite possible, through intelligent methods of cultivation, of cropping, and of fertilization, to change the conditions maintained by soils by changing their physical texture. It is likewise possible that we shall be able in time to control the amount of water taken up from a soil and transpired by plants. In a soil containing much water it should be possible to prevent the plant taking an excessive amount, thus checking the too luxuriant growth of vegetation, or in a soil containing a small amount of moisture to induce the plant to take up more water than it otherwise would. This control will come through the effect of fertilizers and chemicals upon the roots which will stimulate or diminish the transpiration powers of the plant.

SUBSOILING.

Where the amount of rainfall is so small it is obviously important that the soil should absorb all of the rain which falls upon it. It is folly to allow water to flow off the farm, incidentally causing damage by washing, and then spend large sums to put in irrigation ditches to replace it by water which others have allowed to flow off their land. Wherever a drop of water flows off the field it is an indication that the soil is not in a proper physical condition. Where this occurs in a dry soil the main preparation of the land should be as deep as possible, so that the water may be carried down and thus diminish the rapidity of the evaporation and loss from the surface. If deep plowing will not accomplish this object, subsoiling will be found invaluable in opening up the close and compact subsoil. A subsoil plow should be as small and light in all its parts as is consistent with the great resistance it has to encounter. The point should be small and narrow, like the point of a pick, somewhat larger at the back than at the front. It is not necessary to have this large, for any implement which could be pulled through the subsoil would break and loosen it sufficiently to change its physical texture. There are some soils where subsoiling would not only be of no advantage, but in which it might be a positive injury to the land. A light, sandy soil having already an open and porous subsoil would not be benefited by having this subsoil made still more open. A farmer should judge whether subsoiling is advisable by the character and condition of the subsoil, and particularly with a view to the question whether any part of the rainfall flows off the surface.

The conditions in the arid regions are so different from those in the humid portion of the country that the methods adapted to the former are not necessarily well adapted to the latter. The act of subsoiling, the breaking up and stirring the soil to a depth of 12 or 15 inches, tends to dry it out; and unless a rain follows before a crop is put in the subsoiling may work positive injury to the first crop, although the beneficial effects would be felt in the succeeding crops. To secure benefit the first season the subsoiling must be done a considerable length of time before the crop is put in, in the hope of receiving heavy and long-continued rains. It is obvious that the nature of the soil itself will largely determine the depth to which the cultivation should be extended, and the character of the season should determine at what time this cultivation should take place. It is very necessary in this deep cultivation of the soils of the arid regions that care be taken not to turn under a heavy sod or a quantity of organic matter, especially when the season or the soil is dry. In these dry soils a heavy sod or a lot of trash or stubble will not readily decay when turned under; indeed, it may remain undecayed for several years. In this condition it will break off capillary connection with the subsoil, so that if the crop is planted on the upturned sod it may actually perish for lack of moisture. It is a very common experience, nevertheless, with farmers on the plains that where the sod is broken very shallow, so shallow that the crop roots below it, the upturned sod acts as a very efficient mulch to prevent evaporation, and so increases the yield of crops.

After a soil is once deeply prepared, the after cultivation of the crop should be as shallow as possible in order to maintain a mulch of loose, dry soil over the surface to check evaporation, yet to keep this mulch as thin as possible so as not to dry out more of the soil than is absolutely necessary. While cultivation should thus be very superficial, it should be frequent and continued well into the fruiting period of the crop. The old rule of giving one cultivation after each rain is not sufficient.

Thorough preparation of the land, with subsoiling where this is necessary to break up a compact subsoil, followed by shallow but frequent cultivation of the surface, will undoubtedly make the crop much safer and surer in the arid and semiarid regions of the West.

WATER AS A FACTOR IN THE GROWTH OF PLANTS.

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Of all the factors influencing the growth of plants, water is beyond a doubt one of the most important. Plant physiologists have long recognized this fact, but it is only recently that farmers, fruit growers, and others interested in the growth of crops have come to fully realize its importance. As an indication of the growing interest in this subject we may cite the agitation now being made in behalf of irrigation. Irrigation at one time was considered for the most part in connection with the production of crops in the arid regions or in sections where the yearly rainfall is not sufficient for the best development of our agricultural crops. Now nearly every section of the country is more or less interested in the subject. In Florida, where the average yearly rainfall is about 55 inches, or nearly three times as much as in some sections of the West, thousands of dollars are being spent every year for irrigation. The chief reason for this is that although the yearly rainfall is sufficient to grow any ordinary crop, yet it is distributed in such a way that the best conditions for plant growth are not furnished. It is here that irrigation plays an important part, for if just the right amount of water can be furnished at the proper time, other conditions being favorable, the plant immediately responds and a better growth is the result. The whole problem of the proper use of water and its effect on the plant is a complicated one, and until it is better understood by farmers themselves we can not hope to attain the highest development in agricultural pursuits.

The plant may be likened to a complicated and exquisitely sensitive machine, depending largely for its ability to do work on four factors, namely, heat, light, food, and water. If these are furnished in just the right amounts and at just the right time there is harmony in all parts of the machine, and as a result the greatest amount of work is performed; if, however, any one or all of the factors are deficient or excessive, then the perfect working of the machine is destroyed, and its ability to do what is required of it is impaired. In other words, certain diseases appear; or if the plant does not, strictly speaking, become diseased, the growth of the various parts may be unbalanced, resulting in a development which is so different from what is wanted as to have little practical value. Thus leaves and wood may be produced

at the expense of the fruit, or the reverse may be the result of the unbalanced condition of the factors mentioned.

In field culture, heat and light can not well be controlled, but food and water may be to a certain extent, the latter either directly, by supplying it artificially, as in irrigation, or indirectly, by selecting soils having a capacity for moisture best suited to the crop or crops to be grown. Our object, however, is not to discuss these questions, but rather to point out the important part that water plays in nearly every vital process of the plant, in the hope that what is said may awaken the interest of farmers, fruit growers, and others in a much-neglected line of study. We shall not give an exhaustive treatise on the subject, nor attempt to present any specially new facts. Our purpose is simply to bring together some of the knowledge already familiar to vegetable physiologists but as yet little known to those interested in the practical side of plant production.

WATER IN GREEN PLANTS.

The fact that green plants lose a large proportion of their weight in drying is familiar to all. This loss is made up largely of water, the amount of which, compared with the dry substance found in plants, is very great. Thus in every 100 pounds of fresh meadow grass there is found 60 to 80 pounds of water. In 100 pounds of red clover there is often as high as 86 pounds of water, while in such plants as lettuce, cucumbers, cabbage, onions, etc., there is often as much as 95 to 98 pounds of water in every 100 pounds of fresh material. The seeds of plants do not contain as much water as the leaves, stems, and other vegetative parts. Wheat, rye, and oats contain about 14 per cent each, while corn contains about 12 per cent. This comparatively small amount of water contained in the seed is one of the reasons why the latter will remain dormant so long. As soon as the seeds are brought into a moist place, and other conditions for growth are present, they absorb large quantities of water and soon begin to germinate.

It is impossible at ordinary temperatures to dry out all the water held by plants. Most air-dried plants contain as much water as ordinary seed, and this can be removed only by a prolonged exposure to high temperatures.

We see from the foregoing that water forms a large proportion of the actual weight of all plants, and its importance, therefore, in this connection is at once apparent.

RELATION OF ROOT DEVELOPMENT TO WATER SUPPLY.

All our agricultural plants obtain their water exclusively through the roots. That leaves do not absorb water to any appreciable extent under normal conditions of growth has been so fully demonstrated as to need no discussion here. Accordingly, it needs little argument to prove that a well-developed root system is of the highest importance

to the welfare of the plant. There is usually a rapid development of these organs in the early period of growth, and if the proper moisture conditions are present at this time the chances are that a root development favorable to the future growth of the plant will be attained. It should be pointed out, however, that the development of the roots and the form which they may take will be modified by other conditions, and it may be possible to take advantage of these in order to insure a proper water supply as the plant grows older. For example, the distribution of food in the soil may have a very important bearing on the production of roots as well as the position they assume. An interesting experiment bearing on this point was made by Nobbe, a German investigator. He grew a number of corn plants in poor clay soil, contained in glass cylinders. In each cylinder of soil a certain amount of fertilizer was put, in each case in a different position, so as to observe its effect on the growth of the roots. When the plants were nearly four months old the vessels were placed in water and the soil carefully washed from the roots. They were then suspended in water and took nearly the same position they had in the soil. Where the fertilizer had been uniformly mixed with the soil the roots grew equally through the whole mass. Where the fertilizer was placed in a horizontal layer about an inch below the surface the roots formed a mat in this layer, those that extended through being slender and not greatly branched. Where the fertilizer was placed in a horizontal layer at about half the depth of the vessel there was a spheroidal expansion of the root system at this point. Where the layer was placed at the bottom of the vessel the roots were slender and not much branched above, but at the bottom they formed a mat. When the fertilizer was placed around the cylinder of earth next the sides of the jar the external roots were greatly branched, forming a cylindrical nest, but the inner roots were not much developed. When the fertilizer was put in a central vertical core the inner roots were greatly developed, while the outer ones were much less so.

These facts and others of a similar nature show the importance of studies in this direction. It would be especially valuable in the West, and in other sections of the country liable to great variations in the water supply, to be able to control to some extent the character of the root systems of our agricultural plants. If this could be done by methods of cultivating the soil or of distributing the food, where food is used, there is no doubt that the water supply could in a measure be controlled. In this connection it is also important to bear in mind that the best development of the roots and of the plant as a whole is attained only when the water supply approximates a certain amount. This amount will vary with different plants, soils, temperatures, etc. For example, roots produced in very wet soil will not live when the latter dries out to any extent, and in consequence the plants grown under such conditions will suffer. On the other hand, roots produced in dry

soil will not live long if the latter is made excessively wet for any length of time. All these things of course have a marked effect on the development of the plants and the various parts of the same. The total product is not only made to vary by the amount of water at the disposal of the plant, but the proportional amounts of the various organs are also made to vary. Thus in the case of wheat, rye, barley, and other similar plants, a certain amount of water will not only produce the greatest yield of both grain and straw, but will also influence growth so as to give the maximum amount of grain with the minimum amount of straw.

It has been found that when the water in a soil amounts to 80 per cent or more of its water-holding capacity it is detrimental to the plants. Ordinary plants do best when the water in the soil amounts to from 40 to 60 per cent of the water-holding capacity. The water-holding capacity of a soil is the amount of water that a given weight, say 100 pounds, of the soil will contain when all the space between the grains of soil is filled with water. For example, a cubic foot of a very sandy soil has been found to contain about 40 per cent by volume of air space; when all this space is filled with water the sand will contain four-tenths of a cubic foot of water. A hundred pounds of such soil, when all the space between the grains is filled with water, contains about 20 pounds of water. In the same way wheat soil has been found to contain about 31½ pounds of water in every 100 pounds of the fully saturated soil. The amount of water in this soil most favorable to the growth of wheat is from 40 to 60 per cent of 31½ pounds, or from 12½ to 19 pounds per 100. The water-holding capacity of heavy clay soils is about 44.2 pounds of water in 100 pounds of saturated soil. The most favorable condition for plant growth in such soils is when they contain from 16 to 24 pounds of water in 100 pounds of the saturated soil.

It is easy to see why the conditions in a soil having all or nearly all the space between the grains filled with water are detrimental to plant growth. Under such conditions the roots are immersed in water and the soil is very poor in oxygen. On the other hand, when only a part of this space is filled with water the roots are not immersed, and there is a sufficient supply of oxygen. These questions, however, more properly belong to the realm of soil physics, and therefore need not be discussed in detail here.

STRUCTURE OF THE PLANT AND HOW IT OBTAINS WATER.

In order to get a clear idea of the absorption of water by the plant and its movement in the same, it will be necessary to consider, very briefly, its general structure. In all the plants with which we are concerned the roots consist of a central axis of elongated, rather thick-walled cells and vessels, as shown in cross section in figure 12. Around this axis is a rather thick cylinder, composed of layers of soft, thin-walled cells (*p*), which have a great affinity for water. Surrounding

these and forming the outer covering of the root is the epidermis (*e*); many of the cells composing the latter grow out into relatively long projections, known as root hairs (*h h*). These adhere closely to the particles of soil and absorb the film of water adhering to them.

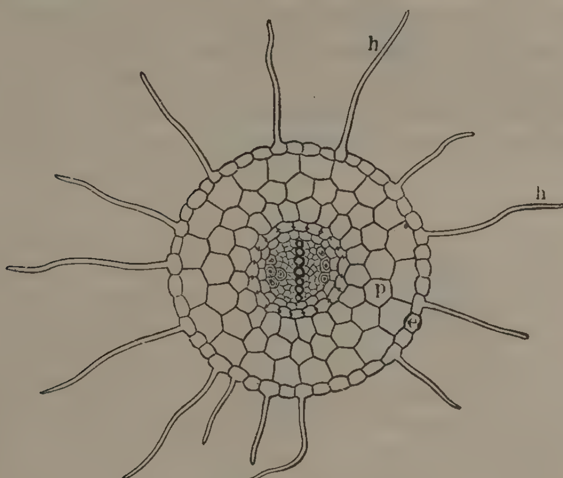

FIG. 12.—Cross section of root.

The absorption of water is well shown in figure 13, taken from Sachs's Lectures on the Physiology of Plants; *e*, on the right of the figure, is the

FIG. 13.—Root hair in the soil, showing absorption of moisture.

epidermis of the root; *h* is a root hair forcing its way in between the grains of soil, *s*, shaded dark in the drawing; the larger rounded white spaces, *a a*, represent air; and the waved lines, *w*, surrounding the par-

ticles of soil and inclosing air bubbles, represent water held to the grains by surface attraction. All are greatly magnified. At the points marked *c* there is close contact of the root hair with the grains of soil. The root hairs, like the grains of soil, are also covered with a thin layer of water, and their walls are saturated with it. Wherever the particles of soil come very close together or touch, the spheres of water surrounding them unite at these points, thus forming a network of the water envelopes of the soil grains. Now, if there is no disturbance in the soil due to evaporation or absorption, this network of water will be held at rest by the attraction of the soil particles; but if any portion of

FIG. 14.—Root hairs.

it is removed, the soil particles that have less will immediately draw from those that have more, so that there will be a movement of water throughout the whole system toward the point where the water is taken away. We will now suppose the root hair, *h*, gives up a part of its water to the cells of the main root; it then absorbs water from the layers with which it comes in contact in the soil, and there is in consequence a movement of the entire water system in the soil toward the root hair until equilibrium is restored. It is evident from this that a plant may draw water from a much larger area of soil than that with which the root system comes in direct contact.

Figure 14 shows a number of root hairs cut from the root and highly magnified. Most of the soil particles have been washed away, but some adhere so closely that they can not be removed without breaking the hairs. This close connection is partly due to the dissolving action which the hairs exercise on the soil grains.

It must be understood that the water absorbed by roots is not pure, but contains in solution small quantities of all the soluble compounds in the soil; some of these are absolutely necessary to the growth and maturation of the plant. Ordinary well water contains all the substances absorbed by the plant in about the same degree of concentration in which they are found in the soil, viz, one to two parts of solid matter to one thousand parts of water. The plant does not necessarily absorb the solution in this proportion; it may absorb more or less, according to circumstances. It may absorb the compounds in the soil without taking up any water, or, on the other hand, it may absorb water without taking up the compounds, depending upon certain physical and physiological conditions. The compounds thus taken up are estimated in the plant as ash. The amount of ash varies greatly in different species and to some extent in different individuals of the same species. Furthermore, it may vary greatly with the age of the plant and the organ under consideration. The total amount, however, is usually very small compared with the gross weight of the plant. The amount seldom runs above 18 per cent (it is usually from 2 to 7 per cent) of the dry weight of the plant. However, it is absolutely necessary that the plant have certain parts of this material, and it can be obtained only as it is dissolved in water and absorbed through the roots. From the roots it passes by diffusion to all parts of the plant. In the parts of the plant above ground, i. e., the stem and branches, the woody portions form a framework which supports the other tissues, made up of more or less soft-walled cells. The outer layers of these cells form the epidermis or outer covering of the plant, and this is usually developed so as to protect the underlying cells from injury, especially through the loss of water.

Through the epidermis of the leaves and sometimes also of the stems, there are minute openings into the spaces between the inner cells of the leaf, for the cells in a plant in a general way may be likened to potatoes in a sack, touching only in places, though the union is relatively very much closer between the cells of a plant than it is between potatoes in a sack. The sack represents the epidermis, the potatoes the cells, and the spaces between the potatoes are comparable to the intercellular spaces.

Figure 15 shows a piece cut from a common leaf and greatly magnified; *u* is the upper and *l* the lower epidermis; the cells with the dark bodies, *c c*, within are the starch-manufacturing cells; *i i* are the spaces between them; the little oval openings, *s s*, in the lower epidermis are the breathing pores (stomata); at *s′* one is shown cut through, opening

into an intercellular space; the two cells bordering the opening are the guard cells.

The breathing pores allow the entrance into the plant of air and certain gases, which, through the intercellular spaces, come in contact with every cell. The intercellular spaces and the larger and older vessels are usually filled with air. The cells, however, are so closely in touch that water and whatever is in solution may pass readily from cell to cell by diffusion. If any cell lacks water, sugar, or any other material in solution it immediately takes it from neighboring cells, and these in turn take from others that have more, so that the equalization goes on throughout the whole plant, and different materials are moving toward the parts of the plant where they are used.

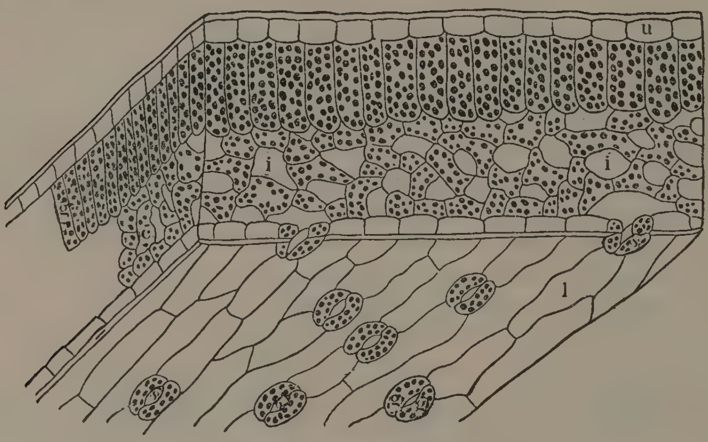

FIG. 15.—Section of leaf.

RELATION OF WATER TO GROWTH.

The growth of the plant is nothing more than the growth of the cells composing it. The cells may increase in number and they may increase in size. Supposing that the cells are supplied with all the necessary materials in solution required for growth, and that the external conditions are favorable, there is still one very essential condition—there must be a sufficient supply of water to keep every cell thoroughly distended. The cell at first may be compared to an elastic sack, but after a time its wall thus distended becomes more or less thickened, loses most of its extensibility, and the increase in size becomes fixed. If, however, before this occurs the internal pressure or turgidity of the cell is lessened by loss of water the cell shrinks in proportion to the decrease, and unless the pressure is again renewed, may become fixed in this smaller condition. This loss takes place as a result of evaporation from the foliage and other green parts of the plant, and goes on from the very beginning of growth. If the evaporation goes too far the cell will pass into a flaccid condition, which causes the plant to wilt

and unless water is furnished, so that the cells may again become turgid, the plant soon dies.

It is evident, therefore, that the rapidity of the increase in size of a plant depends on the degree of turgidity of the cells, other conditions being favorable. The turgidity may be just sufficient to keep the plant from wilting, in which case the growth will be very small. Plants may, therefore, suffer for water long before they show it by wilting. It has been observed that plants growing in certain kinds of sandy soils almost cease growing whenever in May or June there occurs a series of warm, rainless days, accompanied by dry winds. The development of young clover, for instance, on such soils will come almost to a standstill, but it will not begin to wilt for a long time. It wilts on stony ground first; then in a few days the whole field wilts, and the crop is destroyed.

On the other hand, plants may, under certain conditions, absorb too much water, not only filling and distending the cells, but filtering through the cell walls into the intercellular spaces; the plant then becomes water-logged and has a more or less transparent look. If this intercellular water is not removed by evaporation the plant soon suffers from lack of sufficient oxygen and carbonic acid gas. At other times too great turgidity causes abnormal swellings on the leaves and stems. The walls stretch so far that they break, the water escapes, and the cells dry up and die. Occasionally throughout the whole plant the turgidity is so great that the cell walls stretch out of proportion to the ability of the cell contents to make new walls. The tissues therefore become thin and imperfectly formed. Such plants are easily killed by dry weather and readily succumb to the attacks of parasitic fungi and other disease-producing agents, which are usually active at just such times. In other words, the conditions least favorable to the growth of the plant or host are as a rule the ones best suited to the rapid development of certain of its parasitic enemies.

From what has been said it is evident that turgidity must depend primarily upon the absorption of water from the soil, and as turgidity is necessary for growth there is an intimate relation between the latter and the absorption of water by the roots. The amount of water necessary to keep the cells at maximum turgidity would be comparatively small if it were not for the fact that evaporation is constantly lowering the quantity. The growth of the plant, therefore, depends largely on whether or not the roots are able to supply the demands made by evaporation from the foliage and at the same time keep the cells in the necessary condition of turgidity.

LOSS OF WATER BY EVAPORATION FROM THE FOLIAGE.

Under ordinary conditions plants lose very large quantities of water by evaporation, it having been shown, for example, that in a dry, hot day a grass plant will lose an amount of water equal to its own weight.

Ordinary meadow grass is about 70 per cent water, and estimating the crop of hay at 2 tons per acre, the weight of the fresh grass, not counting the roots, would be about 6½ tons. This would represent the amount of water evaporated by an acre of grass in a dry, hot day. Hellriegel estimates from many observations that about 310 parts of water pass off by evaporation for every part of dry substance added to a plant. In 2 tons of hay there are 3,808 pounds of dry substance. According to Hellriegel's proportion, therefore, 1 acre of hay would evaporate about 527 tons of water during the season of growth. An average crop of wheat is 720 pounds of grain and 1,500 pounds of straw to the acre; allowing 15 per cent of water in the air-dry material, there would be produced 1,887 pounds of dry material. During its season of growth this crop would evaporate about 261 tons of water. Other crops will lose nearly in the same proportion. One inch of rainfall per acre is equal to about 100 tons of water. The hay crop, therefore, evaporates an amount equal to only about 5¼ inches of rainfall, and a wheat crop about 2⅗. This of course is only an average. In very moist times either crop would lose less in proportion to the amount of dry substance and in very dry times more. In any case, however, it is seen that plants of this class actually evaporate only a small proportion of the water that falls during the growing season.

The problem, therefore, which presents itself is how to make available to the plant more of the water which falls. This may be accomplished in four ways: (1) By methods of cultivation and of fertilization of the soil in order to keep the water from running to waste; (2) decreasing the evaporation from the soil by the same means and possibly also by mulching; (3) decreasing the evaporation from the plants; and (4) by conserving the water and using it in irrigation. The first two lines of investigation and the last belong particularly to the domain of soil physics; the third, while intimately connected with soil physics, belongs more especially to plant physiologists for solution. It may not be out of place, therefore, to point out some of the means by which evaporation from plants may be controlled.

CONTROLLING EVAPORATION.

As already shown, some of our agricultural plants evaporate 310 parts of water for every part of dry substance made. It must not be concluded from this fact, however, that the plants have to evaporate this much water in order to store the normal amount of dry material. On the other hand, it has been demonstrated in practice and by experiment that the amount of dry substance stored and the vigor of the plant is greater in proportion as evaporation is decreased, other conditions remaining the same.

Most of the water evaporated by growing plants is lost, at least in the middle and later stages of growth, through the stomata or breathing pores, situated in the epidermis of the leaves and opening into the

intercellular spaces, as before described and as shown in figure 15. These pores may open and close, under certain conditions, by the contraction or expansion of the guard cells. When the stomata are open, as they usually are in bright light, there is free access of the gases in the air to the starch-manufacturing cells of the leaf. One of the gases (carbon dioxide) taken in this way is the main ingredient of starch and sugar, and in fact furnishes the material which makes up the larger per cent of the dry weight of the plant. Vegetable physiologists are agreed that the main purpose of the stomata is the admission of this gas and one other, oxygen, to the working cells of the leaf. The air in the intercellular spaces is always saturated with moisture, especially when the leaves are in bright sunlight. When the stomata are open the moisture escapes to the dry outside air, just as it may escape from a moist greenhouse when the ventilators or doors are opened for ventilation. We must have fresh air in the greenhouse, but we can not get it without losing some of the moisture. The rapidity with which the moisture in the greenhouse will pass out depends on the extent to which the ventilators are open, the amount of moisture already in the outside air, and the rapidity with which the air next to the ventilators, and therefore more highly charged with water from the damp air inside, is carried away by the wind. The same conditions hold for the plant. The evaporation, which may be looked upon as a sort of necessary evil, will be less rapid in moist air than in dry air, and will be increased by air currents or wind. If we can increase the amount of moisture in the air we can decrease the evaporation from the plants with which it comes in contact. This suggests the use of trees, especially in sections where hot, dry winds prevail, as a means of breaking the force of the wind and moistening and cooling the air.

Another direction in which we may possibly hope to gain control over loss of water by plants is by increasing the power of the cells of the plant to hold on to the water which they contain, and in this way to resist evaporation more effectively. For many years it has been known through the work of Senebier, Sachs, Burgerstein, Vesque, and others that the presence of various salts and acids in the soil has a marked influence, under certain conditions, on the evaporation of water from the plants whose roots were exposed to the solution of the salts. In some cases the effect was to increase evaporation and absorption, in others to decrease it. The problem needs to be reinvestigated with the practical end in view of increasing absorption and decreasing evaporation. Some late investigators have claimed that the water-holding power of the cells is increased by spraying the leaves with certain solutions, especially Bordeaux mixture. This is certainly true under some conditions, but not so in all cases. It, however, opens up another line in which we may hope to gain some knowledge of the methods of controlling evaporation.

SUMMARY.

The facts presented show—

(1) That water makes up the largest proportion of the weight of green plants, indicating at once its great importance.

(2) That water, with the food which it contains, is obtained by plants exclusively through the roots, and therefore a well-developed root system is essential to the best development of the plant.

(3) That the development of root systems may be controlled in various ways, thereby increasing or decreasing their ability to absorb water and food from the soil.

(4) That a saturated soil is detrimental to the growth of roots; a soil about half saturated is most favorable to their growth and therefore favorable to the growth of the whole plant.

(5) That growth is dependent on the turgidity of the cells, and turgidity is dependent on the absorption of water by the roots.

(6) That the water absorbed by roots is continually being lost by evaporation from the leaves. If the loss is equal to or greater than the absorption, the plants will cease growing, and unless the absorption is increased or the evaporation decreased the plants will die.

(7) That evaporation may be controlled by increasing the amount of moisture in the air, by protection from hot winds, and by the use of certain substances in the soil or on the leaves to enable the plant to hold on to the water that it has.

Finally, then, an accurate knowledge of the relation of water to the growth of plants will enable us to control more fully the development of the plant as a whole, and also the relative growth of its parts. It will show us how to so modify the growth of the plants that they may be able most successfully to withstand adverse conditions and produce the most valuable substance for a given amount of labor.

MINERAL PHOSPHATES AS FERTILIZERS.

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APATITES.

The earliest forms of mineral phosphate used for fertilizer were the apatites.[1] These phosphates occur either in a crystalline form or massive, and are of very wide distribution. In this country they are found in Maine, New Hampshire, Massachusetts, New York, New Jersey, Maryland, Delaware, and North Carolina. They occur in large quantities in Canada, where immense beds exist. Apatite contains, in round numbers, 40 per cent of phosphoric acid and about 50 per cent of lime, and is usually associated with a certain quantity of fluor spar. Some beds contain a considerable amount of chlorine, and nearly all contain traces of iron, alumina, and magnesia. Some forms also contain considerable quantities of manganese. The mineral known as phosphorite is almost the same in chemical composition as the apatites.

COPROLITES.[2]

Phosphate of lime occurs very largely in nodules, which are probably of organic origin, and these spheroidal masses are called coprolites. They sometimes present a spiral or other peculiar structure, due to their animal origin. The nodules are of all sizes from minute grains up to masses weighing as much as a ton. They consist essentially of phosphate of lime, varying from 50 to 60 per cent, and with a greater or less quantity of carbonate of lime. They also contain a considerable amount of organic matter, derived from animal remains, and the rest of the mass is made up of sand and other accidental impurities. These nodules often contain remains of marine life, such as sharks' teeth. At the present time the coprolite phosphates are found chiefly in North Carolina, Alabama, and Florida, though it is probable that they will be discovered in many other parts of the United States.

PHOSPHATE ROCK.

Immense deposits of phosphate rock, both hard and soft, are found in many parts of the United States. The most important of these deposits, from a commercial point of view, are those of South Carolina

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[1] The name "apatite" is derived from a Greek word which signifies *to deceive*, inasmuch as, on account of the color of the mineral, which is often of a blue or green tint, it was mistaken by the early mineralogists for other minerals.

[2] The term "coprolite" signifies fossil excrement. It is certain, however, that the deposits are not of that character, but are more likely bone masses rounded by the action of water.

and Florida, although other deposits of great promise have been found in North Carolina, Virginia, and Tennessee.

The amount of phosphate rock mined in the United States in 1893, with the value thereof at the mines, is given in the following table, taken from the Mineral Resources of the United States, edition of 1893:

	Quantity.	Value.
Florida:	*Long tons.*	
Hard rock	215, 685	$1, 117, 732
Soft rock	13, 675	64, 626
Land pebble	86, 624	359, 127
River pebble	122, 820	437, 571
Total	438, 804	1, 979, 056
South Carolina:		
Land rock	308, 435	1, 408, 785
River rock	194, 129	748, 229
Total	502, 564	2, 157, 014
North Carolina:		
Conglomerate	7, 000	21, 000
Grand total	948, 368	4, 157, 070

The first phosphate mined commercially in South Carolina was in 1867, amounting to 6 tons. The largest quantity ever mined in any one year was in 1889, amounting to 541,645 tons. The total amount of fertilizers, chiefly raw phosphate rock, exported to foreign countries for the fiscal year ending June 30, 1893, was 460,062 tons, valued at $3,927,343. The countries to which the chief quantities of raw phosphates were shipped were Germany and Great Britain. The amount sent to Germany was 149,600 tons, and the amount to Great Britain 209,065 tons.

The quantity of crude phosphates and other phosphatic substances imported into the United States for fertilizing purposes in 1893 was 106,549 tons, valued at $718,871. The amount of guano, which consists largely of phosphate, imported in 1893 was 5,856 tons, valued at $97,889. The largest amount of guano imported into the United States in any one year was in 1868, amounting to 99,668 tons, valued at $1,336,701. The largest amount of crude phosphate and other phosphatic substances, used for fertilizing purposes, imported into the United States in any one year was in 1882, amounting to 133,956 tons, valued at $1,437,442.

The average cost at the quarry of the phosphates mined in the United States in 1893 was $4.42 per ton.

The Florida phosphates are of four distinct types, viz, hard rock, soft rock, land pebble, and river pebble. The pebble phosphates are deposits of spherical masses of varying size, possibly of coprolitic nature, which occur either on the land or collected in cavities in the water courses, where they have been washed by the streams. Some of

the soft rock is of such a texture that it can be very easily crushed, and thus cheaply prepared, in a finely divided state, either for treatment with sulphuric acid for the purpose of making superphosphates or for direct application to the soil.

The Tennessee phosphates have been only recently discovered, and their exact extent is not yet known. From the mines already opened, however, it seems probable that these deposits are the most extensive in the United States. They are situated, so far as known at the present time, in the counties of Lewis, Hickman, Perry, and Wayne. The center of the deposit is about 70 miles southwest of Nashville. It has been estimated that within a distance of 5 miles of the Nashville, Chattanooga and St. Louis Railroad there are 100,000,000 tons of this phosphate rock. The daily output at present is about 300 tons, but it is rapidly increasing.

At present most of the output is shipped by rail, but it is the intention of some of the operators on the Duck River to open a water route to Mississippi and New Orleans by means of the Duck, Tennessee, and Mississippi rivers. When this is accomplished it is estimated that the rock can be laid down in New Orleans at a cost of transportation not to exceed $1.75 per ton.

The phosphates of Tennessee differ from those of Florida in being found in stratified veins instead of pockets and beds. Some of the rocks are quite rich in phosphoric acid. In the analyses of 30 samples of Tennessee phosphates examined in this laboratory the highest per cent of phosphoric acid found was 37.07, corresponding to 80.92 per cent of phosphate of lime. The average content was 17.70 per cent of phosphoric acid or 38.64 per cent of lime phosphate.

CONSTITUENTS OF PHOSPHATE ROCK.

In phosphate rocks the chief constituent from an agricultural point of view is phosphate of lime, chemically known as tricalcium phosphate, and often spoken of in fertilizer circulars and bulletins as "bone phosphate of lime." Calcium phosphate varies in quantity in commercial phosphates from 30 to 90 per cent. The latter purity, however, is very seldom reached, the great majority of the commercial phosphates ranging from 40 to 70 per cent of calcium phosphate.

In addition to this they contain certain quantities of carbonate of lime, small quantities of phosphates of iron and alumina, often considerable quantities of fluor spar, and finally sand and other impurities. There are certain phosphates, however, produced largely outside of the United States, which consist almost exclusively of the phosphates of iron and alumina, viz, such as those known as Redonda phosphates, from the island of Redonda. It is also reported that large deposits of iron and alumina phosphates have been discovered in Virginia, and that they exist already in a powdered state, well suited without further preparation, for application to the soil.

The value of a natural phosphate is largely determined not alone by the percentage of phosphoric acid which it contains, but also by the amount of other materials therein. Especially is this true when the phosphates are to be used for the manufacture of that grade of fertilizers known as superphosphates or acid phosphates, which is accomplished by treating the natural phosphates with oil of vitriol (sulphuric acid). If a natural phosphate, for instance, contain a large quantity of carbonate of lime, this material will consume an equivalent portion of sulphuric acid and thus require a much larger quantity of this acid for conversion into superphosphate. Even if the quantity of phosphates of iron and alumina be considerable, the sulphates of iron and alumina which are formed dry poorly and render the residue unfit for the market. The fluoride of calcium is likewise decomposed by the sulphuric acid and hydrofluoric acid set free. The most suitable material, therefore, for making superphosphates is a phosphate rich in tricalcium phosphate, containing only a moderate amount of carbonate, or one which contains as impurities chiefly sand or silica. The natural phosphates of iron and alumina are well suited for direct application to the soil when they can be obtained in a finely divided state. There is no method of grinding, however, which produces a phosphate as well suited to the nourishment of plants as the material which is produced by chemical precipitation.

DIRECT APPLICATION OF PHOSPHATES.

Experiments have been conducted in this country and in Europe for many years to determine the applicability of natural phosphates in a finely divided state directly to the soil. The greatest difference of opinion still exists in regard to the availability of such phosphates. From a great amount of data which has been collected the following conclusions may be safely drawn:

(1) No kind of natural phosphate is of much value applied directly to the soil, unless in a very finely divided state.

(2) Natural phosphates which consist chiefly of the calcium salt are of very little value when applied directly to soil deficient in organic matter or containing large quantities of carbonate of lime.

(3) Natural calcium phosphates in a finely ground state can be applied with great benefit to soils consisting essentially of vegetable mold or very rich in organic matter.

(4) The natural phosphates of iron and alumina are of a much wider application directly than the phosphates of calcium.

COST OF PHOSPHATIC FERTILIZER TO THE FARMER.

It has been seen from the data given above that the actual cost of ordinary phosphates at the mines is not quite $4.50 per ton. The question may then be very properly asked, Why is the cost of phosphates as used by the farmers so high? The increased cost of the

phosphates used as fertilizers arises chiefly from three causes: First, the cost of grinding the phosphate to a fine powder; second, the cost of treating it with sulphuric or phosphoric acid, in order to render the phosphoric acid soluble; and third, the cost of transportation.

It would be impossible to give any rule which would fix the value of a ton of phosphatic fertilizer. In many of the States the bulletins on fertilizers give the cost per pound of phosphoric acid present in any given sample. This price, however, must necessarily vary from year to year with the cost of production, cost of treatment, and cost of transportation. In general it may be said that at any considerable distance from the mines the value of available phosphoric acid in a superphosphate is about 5 cents per pound.

WHAT IS MEANT BY "AVAILABLE PHOSPHORIC ACID."

The term "available phosphoric acid" is one which is rather difficult to define. Presumably, it applies to the phosphoric acid present in a given fertilizer which is capable of being directly assimilated by plants. It does not include, as a rule, any of the phosphoric acid which is not in a state to be directly absorbed, although such phosphoric acid may, by natural decomposition in the soil, become ultimately available for plant nourishment. It is commonly understood now that available phosphoric acid includes all the phosphoric acid soluble in water, together with that portion which is sometimes called "reverted phosphoric acid," and which is soluble in a solution of citrate of ammonia of given strength and applied in a given way. It is hardly fair, however, to reject as of no value at all any additional phosphoric acid which the sample may contain. For instance, in the case of ground bones none of the phosphoric acid present is soluble in water, and sometimes only a very little in citrate of ammonia; yet the phosphate of the bones is quite available and is easily assimilated by the growing plant. A discrimination, therefore, should be made in all cases between a bone phosphate and a phosphate prepared from minerals. Again, in mineral phosphates there is a wonderful difference in assimilability even in those forms of phosphate insoluble in water and citrate of ammonia. Some kinds of soft phosphatic rock appear to be much more readily assimilated by plants than others. For instance, the apatites seem to have very little power of nourishing plants unless they have been decomposed by sulphuric acid, while, on the other hand, certain forms of soft phosphates have a considerable nourishing power. It is therefore impossible to give any hard and fast rule by means of which the availability of phosphates can be determined. In this case it is safe, therefore, for the farmer to rely, at least for the present, upon the data obtained by chemical analysis, and in the case of mineral phosphates to regard those only as beneficial in general which are soluble in water and citrate of ammonia.

At least this is true for ordinary soils deficient in organic matter or consisting largely of sand or carbonate of lime. If, however, the farmer have to do with peat or muck soils very rich in humus and deficient in phosphoric acid, the rule could hardly be regarded as rigid. In such cases any form of soft mineral phosphate, finely divided, would prove highly beneficial, even if yielding little or nothing to treatment with water and citrate of ammonia.

It is doubtful whether any of the methods now in use by the chemist can give an accurate idea of the true availability of phosphoric acid in a fertilizer. In the case of phosphoric acid soluble in water, viz, free phosphoric acid, or an acid phosphate of lime, it is almost certain that when applied to the soil it does not long retain its solubility. This should be regarded as a fortunate rather than an unfortunate fact. Should the phosphoric acid retain its solubility in water, there would be great danger of its being removed through drainage waters by excessive rainfall. When applied to a soil which contains the usual amount of iron and alumina the soluble phosphoric acid readily unites with these bases, forming iron and alumina phosphates, or is converted into the insoluble dicalcic phosphate. These phosphates, while not soluble in water, yet yield their phosphoric acid readily to the demands of the rootlets of plants. The phosphoric acid is thus preserved in a state where it is safe from exhaustion by leaching, and yet in a condition easily available for plant food.

From a practical point of view, therefore, there is no advantage in applying water-soluble phosphate instead of a phosphate soluble in ammonium citrate. The great differences, moreover, in the ease with which phosphates insoluble in water and citrate of ammonia are decomposed in the soil render it difficult to form any accurate judgment of the actual availability of this form of fertilizer. It is certain that the rule which is in force in many of the States, making the insoluble acid valueless for fertilizer purposes, is entirely too exclusive.

On the other hand, these phosphates in most cases can certainly not be regarded as equally available as those soluble in water and ammonium citrate. The origin of the sample has also much to do with the matter. As has already been intimated, finely ground bone, even though insoluble in water and ammonium citrate, will nevertheless yield a part of its phosphoric acid very readily to growing plants.

In general, it may be said that the more nearly the phosphoric acid is in an organic state the more readily available it becomes. The mineral phosphates, however, show the greatest difference in availability when insoluble. On the one hand we have an extreme degree of nonavailability, as is instanced in the crystallized apatites, and on the other hand a high degree of availability, as shown in the finely divided mineral phosphates of iron and alumina. Between these two extremes the ordinary mineral phosphates will be found ranged in different degrees of availability.

Further, as has already been stated, the character of the soil to which the phosphatic fertilizer is applied has much to do with determining its availability. All of these facts must be taken into consideration in attempting to fix the availability of a phosphatic fertilizer by chemical analysis, and in no case is it safe to enforce a rigid rule which, while it might be applicable in one set of circumstances, would be found wholly at fault in another.

SUPERPHOSPHATE, OR ACID PHOSPHATE.

A brief statement of the character of fertilizers known by the name of superphosphates, or acid phosphates, may prove of utility to farmers. On account of the high degree of nonavailability of some of the phosphates, as mentioned in the preceding paragraphs, it has long been the custom among manufacturers to prepare these mineral phosphates, previous to their application to the soil, in such a way as to increase the availability of the phosphoric acid which they contain.

The most common method of securing this result consists in treating the finely ground phosphate with sulphuric acid (oil of vitriol). A large part of the lime contained in the natural phosphate is thus converted into sulphate of lime (gypsum, or land plaster), while the phosphoric acid which was before in combination with the lime is secured, either in a free state or in combination with a lower equivalent of the lime. A normal phosphate of lime, such as is found in bones and in most mineral phosphates, is composed of three molecules of the oxide of calcium (lime) in combination with two molecules of phosphoric acid. Represented chemically, a molecule of bone phosphate or mineral phosphate of lime has the composition shown by the formula $(CaO)_3(P_2O_5)$. The percentage composition of pure phosphate of lime is, therefore, lime (CaO), 54.19 per cent, and phosphoric anhydride (P_2O_5), 45.81 per cent.

The first step in the preparation of superphosphate consists in reducing the mineral phosphate to a condition of fineness which will permit its rapid disintegration when treated with sulphuric acid. In practice it is customary to grind the phosphate so it will pass a screen with 70 or 80 meshes to the inch. The finer and more uniform the grinding, the easier and more economical becomes the treatment with sulphuric acid.

Various mechanical appliances are in use for preparing the mineral phosphates for treatment with sulphuric acid. The phosphates are first broken into fine pieces, usually by a Blake crusher. The pieces should be the size of an acorn or smaller. They may then be ground between French burr millstones and the flour sifted through revolving screens, very much as wheat flour is treated. This is the simplest and oldest method of grinding the phosphate. Many modern mills have been invented for the same purpose, all depending more or less upon the same principles. It is estimated by Dr. Francis Wyatt that the actual cost of grinding phosphates, including all expenses for repairs, wear and tear, and interest on the investment, is about $1.50 per ton.

The next step after the grinding of the material is to determine its chemical composition, because the amount of sulphuric acid required for treatment of the phosphate flour depends essentially upon its chemical structure. In the chemical analysis there must be determined the amount of moisture, the organic matter, the carbonate of lime, the magnesia, the amount of phosphates of lime, iron, and alumina, the quantity of sulphate and fluoride of lime, and the percentage of insoluble matter, which is chiefly sand and silicates. With mineral phosphates containing about 80 per cent of the phosphate of lime, from 3 to 4 per cent of the phosphates of iron and alumina, and from 7 to 9 per cent of the carbonate and fluoride of lime the quantity of ordinary sulphuric acid required for 100 pounds is about the same in weight. For each ton of such material, therefore, 1 ton of the ordinary sulphuric acid must be employed. If the amount of carbonate of lime and other acid-consuming materials increase above the amount mentioned, then the quantity of sulphuric acid required would also be proportionately increased.

On account of the fumes of hydrofluoric acid which are emitted upon mixing the ground material containing fluor spar with sulphuric acid, the operation must be performed in a well-ventilated shed where the acid fumes can be carried away by means of some kind of a ventilator. The vessel in which the phosphate flour is mixed with sulphuric acid should be lined with lead, which is practically insoluble in sulphuric acid. The mixer, which is a revolving shaft carrying paddles made of cast iron, is driven by machinery. The appropriate amount of phosphate flour having been placed in the mixer, the sulphuric acid is let into it by means of a lead pipe connected with the sulphuric acid tank, and the whole is thoroughly triturated. After all the acid and flour have been placed in the mixer the shaft is driven rapidly for a few minutes until every part of it is thoroughly stirred and the semiliquid mass is allowed to flow into an appropriate reservoir.

The mixers are very conveniently arranged so as to hold about a ton, while the reservoir into which their charges run may hold 100 tons or more. As it requires only five or ten minutes to mix one charge, when all the facilities are properly arranged, the reservoir may be filled in a day. The material in the reservoir becomes very hot, due to the chemical action taking place between the sulphuric acid and the other ingredients. The temperature rises often above that of boiling water, and it may reach as high as 240° F.

After the chemical action has ceased and the mass begins to cool, it soon becomes hard, setting something after the manner of cement or plaster of paris. At the end of two days it is sufficiently dry and hard to be dug out with picks and shovels. When removed from the reservoir it is piled up in heaps, where it is allowed to remain for about two days, and then is ready for being broken up and ground. This is easily accomplished by appropriate machinery, after which it can be placed in bags and it is then ready for shipment.

The superphosphates formed in this way usually contain from 12 to 14 per cent of available phosphoric acid, and this phosphoric acid exists in various degrees of combination. First, there is free phosphoric acid; second, phosphoric acid combined with lime in the proportion of one molecule of lime and two of phosphoric acid; third, phosphoric acid combined with lime in the proportion of two molecules of lime to two of phosphoric acid; fourth, a little of the phosphoric acid may be left combined in the natural state, in the proportion of three molecules of lime and two molecules of phosphoric acid. The acid salts of lime also contain, in addition, water of crystallization. The free phosphoric acid and the monocalcium phosphate are soluble in water, the dicalcium phosphate in citrate of ammonia, while the tricalcium phosphate which remains undecomposed is insoluble in water and citrate of ammonia.

In the above processes, which have been outlined in a general way, the actual weight of a ton of mineral phosphate is almost exactly doubled by being converted into superphosphate. If the original material contained, therefore, 80 per cent of phosphate of lime, the treated material contains only 40 per cent. Thus the freights are doubled and there is secured a material which, in addition to the phosphoric acid, very probably does not have a sufficient fertilizing value to warrant the payment of so high a rate of freight. It is true that the sulphate of lime, which is always present in large quantities in superphosphates, is valuable in some instances as a fertilizer, and in fact is purchased for that purpose under the name of gypsum, or land plaster. It, however, might be of some advantage to the farmer to apply this substance directly instead of indirectly with the phosphate. For this reason manufacturers have sought to make a more concentrated form of superphosphate and thus diminish the freight charge, which is one of the chief items of cost in fertilizers delivered to farmers.

In order to obtain a high-grade superphosphate and thus diminish freight charges the decomposition of mineral phosphates may be accomplished by the use of phosphoric acid itself in the place of sulphuric acid. This phosphoric acid is obtained directly on the premises by the decomposition of the phosphates by sulphuric acid and the subsequent separation of the phosphoric acid from the product by well-known methods which it is not necessary to describe here. When the phosphoric acid is concentrated to the proper degree of strength, it requires from $1\frac{3}{4}$ to 2 pounds of it to decompose 1 pound of an ordinary mineral phosphate. The decomposition by means of phosphoric acid and subsequent treatment are very much the same as described for the direct decomposition of the phosphate flour by sulphuric acid. In this way a phosphate is produced which will yield from 35 to 45 per cent of phosphoric acid soluble in water and ammonium citrate. Such a fertilizer would be of especial value when it becomes necessary to ship long distances, especially by rail, and farmers would do well to apply to their State chemists and others in charge of the sale of phos-

phates and fertilizers to secure for them in some way a phosphate of this description.

The farmer should remember that it is not always the cheapest phosphate which is the most valuable. What he should especially attempt would be to secure available phosphoric acid at the lowest possible rate. He may give as high as 6 cents a pound for available phosphoric acid in a phosphate which he gets for $20 per ton, while at the same time he might purchase the same material for 4½ cents a pound in a phosphate worth $40 per ton.

PHOSPHATE AS BASIC SLAG.

Another form of phosphate which is coming into extended use in this country as well as in Europe is that which is produced as a by-product in the manufacture of iron and steel. Many iron ores contain a notable quantity of phosphoric acid, which renders the pig iron made from them unsuitable for the manufacture of high-grade iron or steel, when the usual processes of reduction are followed. In order to utilize these pigs, which otherwise would not be very valuable, the basic Bessemer process has been invented. In Europe the process is known as the Thomas process, while in this country it is carried on chiefly under the patents taken out by Jacob Reese.

The principle of the process depends upon the arrangement of the reduction furnaces, by means of which the phosphoric acid in the pig iron is caused to combine with the lime which is used as a flux in the converters. A general outline of the process is as follows:

The pigs which contain from 2 to 4 per cent of phosphorus are melted and introduced into a Bessemer converter, lined with dolomite powder cemented with coal tar, into which has previously been placed a certain quantity of freshly burned lime. For an average content of 3 per cent of phosphorus in the pig iron, from 15 to 20 pounds of lime are used for each 100 pounds of pig iron. As soon as the melted pig iron has been introduced into the converter, the air blast is started, the converter placed in an upright position, and the purification of the mass begins. The manganese in the iron is converted into oxide, the silicon into silica, the carbon into carbonic acid and carbonic oxide, and the phosphorus into phosphoric acid.

By reason of the oxidation processes, the whole mass suffers a rise of temperature amounting in all to about 1,200° F. above the temperature of the melted iron. At this temperature the lime which has been added melts and in this melted state combines with the phosphoric acid, and the liquid mass floats upon the top of the metallic portion, which has by this means been converted into steel. As soon as the process is completed the fused slag is poured off into molds, allowed to cool, broken up, and ground to a fine powder. The whole process occupies only about fifteen minutes. For each 5 tons of steel which are made in this way, about 1 ton of basic slag is produced.

In another process, in order to make a slag richer in phosphoric acid, a lime is employed which contains a considerable percentage of phosphate. Although the slag thus produced is richer in phosphoric acid, it is doubtful whether it is any more available for plant growth than that made in the usual way with lime free from phosphoric acid. In other words, when a basic slag is made with a lime free from phosphoric acid, nearly the whole of the phosphoric acid is combined as tetrabasic calcium phosphate. On the other hand, when the lime employed contains some of the ordinary mineral phosphate, the basic slag produced becomes a mixture of this mineral phosphate with the tetracalcium salt. The mineral phosphate is probably not rendered any more available than it was before.

It is easily seen from the above outline of the process of manufacture that basic slags can have a very widely divergent composition. When made from pig iron poor in phosphorus, the slag will have a large excess of uncombined lime, and consequently the content of phosphoric acid will be low. When made from pigs rich in phosphorus, there may be a deficiency of lime, and in this case the content of phosphoric acid would be unusually high.

It is found also that the content of iron in the slag varies widely. In general, the greater the content of iron, the harder the slag and the more difficult to grind. If the pig iron contain sulphur, as is often the case, this sulphur is found also in the slag in combination with the lime, either as a sulphide or sulphate. No certain formula can therefore be assigned to basic slags, and the availability of each one must be judged by its individual analysis.

The value of a basic slag to the farmer depends largely upon the quantity of phosphoric acid which it contains soluble in a 5 per cent citric-acid solution. Inasmuch as the great value of the basic slags in certain soils and for certain crops has increased the demand for it very largely, there are many imitations of it placed on the market which will be described further on.

This waste material, or phosphatic slag product, contains varying quantities of phosphoric acid, sometimes more than 20 per cent. It is reduced to a fine powder, and is then ready for application without any further treatment. In addition to the phosphoric acid it contains, there are also considerable quantities of lime and iron, usually in a low state of oxidation.

Objections have been made to the use of basic slag for fertilizing purposes on account of the iron which it contains. There are, however, no valid objections which can be based upon this fact. In many soils the addition of iron is a positive benefit, while in all cases the quantity of iron contained in the slag would be too small to produce any injurious effects upon growing crops.

The phosphoric acid in basic slag is different in chemical composition from that obtained in natural mineral phosphates and in bone. As has

already been pointed out, the phosphoric acid in the substances just mentioned is combined in a form which is known to the chemist as tricalcium phosphate, containing three molecules of the oxide of lime, each molecule of it containing three parts of the oxide of lime to two parts of phosphoric acid. In the basic slag, the molecule consists of four parts of oxide of lime to two parts of phosphoric acid. It is therefore known chemically as tetracalcium phosphate. Its composition is chemically expressed by the symbol $(CaO)_4P_2O_5$. This form of combination seems to be much more easily assimilable by plants than the other, and extended experiments have shown that, as a rule, in its application the phosphoric acid is quite as available as that which is present in superphosphates. A large percentage of the tetracalcium phosphate present in basic phosphate slags is soluble in citrate of ammonia, and a still larger quantity in free citric acid. Thus, by the ordinary chem-

FIG. 16.—Effect of fertilizing vegetable soil with phosphates and other substances.

ical tests, it is shown to be more available than the mineral phosphates, and practical experiments in field and pot culture have shown that this is the case.

When basic slags are cooled slowly, they tend to assume a crystalline condition, especially in the interior of the mass, and these crystals represent, more nearly than the other portions, their true composition, but being harder are not so well suited to fertilization.

In figures 16 and 17 are shown the results of experimental fertilizing with phosphates and other substances on the growth of oats in muck soils. In figure 16, pot No. 1 was unfertilized; pot No. 5 had received fine-ground Florida phosphate at the rate of 500 pounds per acre; pot No. 9 the same quantity of fine-ground phosphate, and 300 pounds each of sulphate of ammonia and sulphate of potash per acre; pot No. 10 the same quantity of fine-ground phosphate and 4,000 pounds of lime per acre.

In figure 17, pot No. 23 was unfertilized; pot No. 17 had received fine-ground phosphate, pot No. 18 basic slag phosphate, and pot No. 19 acid phosphate, all at the rate of 500 pounds per acre.

In figure 16 it is seen that the phosphate alone, No. 5, produced as good results as when mixed with other fertilizers, No. 9, and the addition of lime, as shown in No. 10, was a positive injury. In figure 17 it is seen that the fine-ground phosphate, pot No. 17, and the acid phosphate, No. 19, gave the best results, closely followed by the basic slag, No. 18.

In such soils as these, therefore, a fine-ground, soft phosphate is the only fertilizer necessary for oats.

The soil used in the experiment shown in figure 16 had been in cultivation for three years, while that used in the experiment shown in figure 17 was a subsoil which had never been in use.

FIG. 17.—Effect of fertilizing muck soil with different phosphates.

In other soils deficient in lime and iron there is every reason to believe that the application of basic phosphate would at times give better results than that of a superphosphate, on account of the additional quantity of lime and iron conveyed to the soil in the fertilizer employed.

On account of the fact that the basic slag is a by-product in the manufacture of iron and steel, and that it requires no treatment with sulphuric or phosphoric acid to render it available, and that the only expense connected with its manufacture consists in its grinding and in the additional expense of the furnace linings required for its production, it is found that the available phosphoric acid contained therein can be placed upon the market quite as cheap, if not cheaper, than a similar quantity of available phosphoric acid produced by the old process.

It must not be forgotten, however, that the quantity of basic phosphate produced is limited, not by the demand for it as a fertilizer, but by the market for the iron and steel which is the direct product of the manufacture of which the basic slag is only a by-product. There is not much prospect, therefore, of its ever assuming a place in the markets of the world for fertilizing purposes to the exclusion of bone and mineral phosphates.

The quantity of basic slag manufactured and consumed in Germany in 1893 was 750,000 tons, quite equal to the consumption of superphosphates. The quantity of slag produced in England for the same time was about 160,000 tons, and in France about 115,000 tons, making the total production of central Europe about 1,000,000 tons, a quantity sufficient to fertilize nearly 5,000,000 acres. The only place in this country where basic slag has been produced is Pottstown, Pa., and the factory there is not in operation at the present time.

In regard to the amount to be used no definite rule can be given, but from 300 to 500 pounds per acre will usually be found sufficient.

ADULTERATION OF BASIC-SLAG PHOSPHATES.

By reason of the high agricultural value of the basic phosphate slags, it has proved to be very profitable to imitate them by the manufacture of substitutes. These substitutes are essentially fraudulent. They consist chiefly of mineral phosphates of lime or of iron and alumina. It is true they all contain a greater or less per cent of phosphoric acid, but this acid is present in practically an unavailable state. These imitations can be distinguished from the genuine by the solubility of the phosphoric acid which they contain and by microscopic examination. The farmer should at least insist that 75 per cent of the phosphoric acid in a basic slag offered him should be soluble in a 5 per cent solution of citric acid. It should not be forgotten, moreover, in this connection, that genuine slags may differ very greatly among themselves in availability. In one case all the phosphoric acid in the slag may be present as tetracalcium phosphate, of which a considerable quantity is soluble in ammonium citrate, and nearly all of it in a 5 per cent solution of citric acid. Another sample of slag, having the same general appearance and approximately the same percentage of phosphoric acid, may give up only a little of its acid to ammonium citrate, and not more than a quarter or half of it to citric acid. The mere fact, therefore, that a given sample of fertilizer is composed wholly of basic slag is not an absolute guaranty of the complete availability of its fertilizing principles.

Attention has already been called to the importance of the nature of the soil when judging of the availability of phosphatic manures in general, and this rule applies with equal force to basic slags.

It is undoubtedly true that these slags are superior in value to superphosphates in all cases where they are to be applied to naturally wet,

peaty, or marshy soils. Inasmuch, however, as they are soluble in water only to a slight degree, basic slag should in all cases be plowed under, so as to be placed in a portion of the soil where the rootlets of the plants will have access to it.

PHOSPHATES IN MARLS.

The term "marl" itself is of rather wide application. In general it is applied to any pulverulent or semipulverulent deposit containing notable quantities of lime carbonate and existing in a condition fit to apply directly to the field, or to be applied after a simple crushing.

The chief agricultural constituent of a marl is always lime carbonate, although some samples of marl which are placed on the market may have only a small per cent of this material. In so far as the fertilizing properties are concerned in a general way, however, they must be ascribed principally to the carbonate of lime. It is for this reason that marls act in such a beneficial way when applied to stiff clay soils and other soils deficient in lime. Many of the Virginia marls, however, are found to contain, in addition to the lime, considerable quantities of potash and phosphoric acid, while marls from other localities contain also potash and phosphoric acid, the potash being usually in the form of silicate.

The percentage of phosphoric acid in phosphate-bearing marls varies from a mere trace to as much as 4 or 5 per cent. Usually, however, the marls contain from 1 to 2 per cent of phosphate. When marls contain over 5 per cent of phosphate they can hardly be considered under the name of marls, but should then be transferred to the place of natural phosphates. As a rule the farmer can not expect much benefit from the phosphate content of a marl. On account of the small proportion of plant food in marls, they will not bear transportation to any great distance. There are very few marls that are worth, when placed upon the field, more than $4 or $5 per ton, and in the great majority of cases the value is not even so great.

RULES FOR THE APPLICATION OF PHOSPHATIC FERTILIZERS.

It is not possible to give any rigid rule for the use of phosphatic fertilizers applicable in all cases. The character of the soil is, of course, the first thing to be taken into consideration. In most soils there is a sufficient quantity of phosphoric acid already present, if it could only be secured in an available form. In other cases there may be an actual lack of the phosphate in the soil, and this is notably the case in soils composed chiefly of sand, such as are found in many parts of Michigan, New Jersey, and Florida.

A chemical analysis, therefore, does not always give an indication of the actual need of a soil for phosphorus. The analysis may indicate a fair proportion of phosphorus in the soil, and yet it may not show its state of composition and degree of availability. A content of from 0.2

to 0.5 per cent of phosphoric acid in the soil shows an ample supply of that material. It would be useless to state dogmatically a minimum content of phosphoric acid which would render absolutely necessary the use of a phosphatic fertilizer. In general, however, it may be assumed that authorities on analytical chemistry would regard a percentage of less than 0.12 of phosphoric acid as indicating a less than minimum amount necessary to proper plant growth. In soils of good fertility the usual content of phosphoric acid is from 0.2 to 0.4 per cent.

The quantity of a phosphate which is added, however, in a fertilizer, although it might be sufficient for the needs of a growing crop, would increase almost infinitesimally the percentage of phosphate in the soil. As a rule phosphate fertilizers are applied in amounts varying from 300 to 500 pounds per acre, except in rare instances of intensive culture, as in gardens and truck farming. If the fertilizer employed contain an average of 20 per cent of phosphoric acid, which may be allowed as a rule, then in the application of 500 pounds there would be only 100 pounds of phosphoric acid added per acre. When the total weight of soil, taken to the depth of 6 inches, covering an acre, is considered, it is seen that this addition of phosphoric acid would add almost infinitesimally to the percentage. The principle of the use, therefore, of phosphoric acid in the form of fertilizer is based on the assumption that it gives to the rootlets of the plant the phosphate in a form readily available, and not that it increases to any appreciable extent the actual phosphoric-acid content of the soil.

It could easily happen that a field might receive annually 100 pounds of available phosphoric acid per acre without showing at the end of ten years any marked increase in the percentage of this substance in the soil itself. The best rule for the farmer to follow, therefore, is to make an actual test of the needs of his fields by applying fertilizers of different descriptions to small measured areas. It is not possible for every farmer to secure an analysis of the soil of his fields, nor would an analysis of the soil of one field be a fair indication of the needs of another. Where the direct method of experimentation mentioned above, however, could be combined with chemical analysis, together with a study of the physical conditions of the soil, the farmer would have at hand complete data for judging of the actual needs of his fields. It is undoubtedly true that thousands of farmers are paying out annually large sums of money for phosphatic fertilizers and applying them to fields in which there is no deficiency of phosphorus. These phosphatic fertilizers are frequently mixed with other fertilizing materials containing potash and nitrogen, and the good effect produced by the fertilizers may be due to the other materials and not to the phosphorus; but by testing small measured areas with phosphoric acid, with potash, and with nitrogen, or by combinations thereof, the farmer in a year or two can reach a reliable conclusion in regard to the needs of his soil.

FERTILIZATION OF THE SOIL AS AFFECTING THE ORANGE IN HEALTH AND DISEASE.

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Probably the most important question which concerns the orange grower is how to fertilize his trees. In Florida, where the orange soils are mostly very sandy and sterile, and require to be fertilized regularly, it is highly important to understand what elements should be used in fertilization and in what forms it is best to use them. No plant will long withstand improper treatment. In case of slow-growing plants like the orange, where proper treatment prolongs growth and productiveness for centuries, it becomes particularly necessary that correct methods of manuring be used. The condition of tree reflects largely the cumulative treatment of years; in crops which are replanted each year, however, the effect of improper fertilization is probably less noticeable, especially so far as the development of disease is concerned.

In growing annual plants one can early notice results and may profit by experience. A few seasons will suffice to determine about the kind and quantity of fertilizer necessary for them on a particular soil. In the fertilization of the orange, however, the matter is not so easily determined; only the observations of a series of years will give results which can be depended upon. An orange grower may fertilize with one element one year and get good results, but this is no evidence that the same element used the next year or year after year will prove beneficial; it may, indeed, in prolonged treatment, lead to deterioration and disease. It is this difficulty in experimenting and drawing correct conclusions that accounts for the present poor understanding of rational methods of manuring the orange.

The orange appears to be very sensitive to methods of treatment and fertilization, and several of the most serious diseases are either caused or aggravated by errors in these. The present paper is based largely on the experiences of intelligent orange growers and upon such observations as the winter has been able to make in the course of investigations of orange diseases.

FERTILIZING FOR GROWTH AND FRUIT.

Primarily the orange grower desires to know how to fertilize so as to stimulate either growth or fruit production. With oranges, as with many other agricultural plants, one may fertilize in such a manner that

excessive growth is stimulated at the expense of fruit production. A strong nitrogenous fertilizer results usually in much growth and little fruit. This seems to be particularly true if the ammonia is added in an organic form. While trees are young it is probably well to favor the growth of wood principally, but at an age of seven or eight years from the bud, the tree, if it has grown properly, will have attained sufficient size to begin to produce a fair quantity of fruit. It should then be given a slightly modified fertilizer, containing more potash and phosphoric acid and less nitrogen, to stimulate fruit production as much as possible. The so-called chemical manures appear to be much more active in stimulating fruit production than organic manures.

EFFECT ON QUALITY OF FRUIT.

The experience of many orange growers indicates that the quality of the fruit may be largely controlled by fertilization. As oranges are purchased very largely on their appearance and quality, this becomes an important consideration in manuring. Many intelligent growers are coming to believe that the best results can be obtained by giving the trees an application of that element only which seems to be lacking, and not using, as the majority do, a complete fertilizer, in definite proportions, regardless of whether all the elements are needed by the plant or not. If it can be determined by the appearance of the tree and fruit what element is lacking, this would seem to be the most rational way to fertilize.

It seems reasonable to suppose that by careful study pathological characters induced by starvation might be found, which would serve to indicate clearly the lack of any particular element. Some growers claim to be able to recognize these characters now, and are fertilizing largely on this modified plan, taking advantage of what we might call the sign language of the tree. Some of these characters will be mentioned below under the consideration of the different elements used.

EFFECT ON SOIL MOISTURE.

In fertilization at least two factors must usually be considered, the element of plant food supplied and the effect of this upon the soil as aiding it in supplying the plant with moisture. The heavy application, in late fall or early spring, of an organic manure, like blood and bone, which is extensively used in Florida, is liable to lead to injurious effects during the spring drought, if the trees are on high and dry land. On the other hand, such soils might be ameliorated by using substances which attract water and increase the surface tension of soil moisture. Nitrogen, for instance, used in the form of nitrate of soda, and potash, in the form of kainit, would tend to draw up the subsoil moisture and probably aid largely in supplying the necessary moisture during this trying season. The use of organic manures, on the contrary, would only exaggerate the damage produced by drought. If groves are on very

moist land, as is frequently the case in Florida, where the necessity is to lessen the moisture rather than to increase it, some form of organic manure, as muck or blood and bone, might be found of benefit.

EFFECT OF FERTILIZERS ON THE ORANGE IN HEALTH.

The elements which need to be supplied in fertilization to most Florida orange groves are nitrogen, potassium, and phosphorus; or, using the terms in which they are expressed in most analyses of fertilizers, ammonia, potash, and phosphoric acid. The application of lime would also prove of benefit to many groves. Probably no element of plant food used in the fertilization of orange groves should be more carefully considered, with respect both to form and quantity, than nitrogen. It is the most costly and at the same time the most dangerous element to use, as excessive applications are liable to result in extensive dropping and splitting of the fruit or in the production of the serious disease known as die-back, which will be discussed below.

EFFECT OF NITROGEN.

A grower may with considerable certainty determine by the appearance of his trees the condition of his grove in respect to the supply of nitrogen available in the soil. An abundance of nitrogen is indicated by a dark green color of the foliage and rank growth. The fruit shows the effect of an abundance of nitrogen by being, in general, large, with a thick and comparatively rough rind. If the trees have a yellowish foliage, with comparatively small leaves, and show little or no growth, there is probably a lack of nitrogen. In this case there is but little fruit formed, and that formed is small and usually colors early. If the tree is starving from a lack of nitrogen, the foliage will become very light yellow and sparse, and the small limbs will die, as will also the large limbs in extreme cases. If the starvation is continued, no fertilizer being added, the tree will finally die back nearly to the ground and probably die out entirely. The extreme symptoms of general starvation from lack of all elements are probably nearly the same. The nitrogen used in fertilization is commonly derived from mineral or organic sources. Of the former, sulphate of ammonia and nitrate of soda are the forms most used; of the latter, muck, dried blood, blood and bone, cotton-seed meal, tankage, fish scrap, stable manure, etc., are the forms most commonly employed.

INJURIOUS ACTION OF MUCK.

Muck is very commonly applied in considerable quantities either in a raw state or composted with sulphate of potash, etc. Many growers rather fanatically hold to what they term natural fertilization. By this is usually meant giving the tree nourishment in the form in which they suppose it to be derived in nature. It is contended by many that muck is principally decaying vegetable matter, and that as this is the form

of nourishment which the trees obtain in nature, it must be a good fertilizer to use in cultivation. But it must be borne in mind that orange trees as we cultivate them are decidedly not in a state of nature, except that by the cultivation of centuries we have made cultivation and manuring natural conditions which the plant demands. Trees in nature bear fruits for seed to reproduce the species; on the contrary, we grow fruits for market and favor a seedless variety. We want a smooth, thin-skinned, tender, juicy fruit that will sink in water. Nature does not pay particular attention to these characters, so we watch for freaks and sports, abnormal plants, which have the characters we desire, and when found we render these characters permanent by budding. Our aim in cultivation is not to produce the fruit we find in the wild state, but to modify that fruit to suit our purpose. One of the most efficient methods of accomplishing this is to vary the fertilization.

While it can not be denied that muck has in some cases given excellent results, it must be conceded that its extensive use has usually been of doubtful benefit and often has done positive injury. Groves which have had liberal dressings of muck are frequently much diseased and produce light crops; the oranges are usually coarse, thick-skinned, and sour; the productiveness is often lessened by extensive premature dropping of the fruit; the tendency seems to be to bring on die-back, a disease which is of frequent occurrence in groves heavily fertilized with muck. What has been said of muck applies to a greater or less extent to the various forms of organic nitrogen used. The tendency of all organic manures rich in nitrogen is to produce a large growth which is weak and sickly. Growth and not fruit is stimulated, and the fruit resulting is usually of poor quality, inclined to be large and rough, with a thick rind and abundant rag.[1]

STABLE MANURE OF DOUBTFUL UTILITY.

Barn manure is largely used by many growers, who still hold to the tradition that chemical manures are injurious to the plants. The benefits of barn manure in an orange grove are in serious question. The fruits produced by nitrogen from this source are, as above stated, usually large, coarse, thick-skinned, with abundant rag, and of inferior flavor. If barn manure is used—and most growers have a limited quantity and desire to use what they have—it should be spread over the grove lightly, so that each tree receives only a small amount. Where such manure is depended upon as the main element of fertilization, liberal dressings of potash should be occasionally applied; this will tend to correct the evils of an overbalanced nitrogenous fertilizer. What has been said as to the effect of muck and barn manure on the quality of the fruit applies equally to the effects produced by cotton-seed meal, blood and bone, tankage, etc.

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[1] A term applied to the pithy axis of the orange fruit and the membranes separating the sections.

In general, organic fertilizers do not stimulate fruiting to the same extent as the mineral fertilizers. It is probably better economy to apply such fertilizers to annual crops, cereals, garden truck, etc.

MINERAL NITROGEN.

The mineral nitrogen manures, nitrate of soda and sulphate of ammonia, apparently stimulate production of fruit more than organic manures and yet promote a fair general growth. The fruit produced by fertilization with these salts, used in correct proportions with the other elements which it is necessary to apply, is usually of good quality, being solid, juicy, and rich, with thin skin and little rag. Sulphate of ammonia has the effect, growers testify, of sweetening the fruit to a considerable extent. There seems to be little doubt as to the correctness of this view, but why it is so remains in question. The sweetening is probably more marked if there is a slight deficiency of potash. The use of very large quantities of either sulphate of ammonia or nitrate of soda may result disastrously, acting as "chemical poison," killing the trees outright and causing them to throw off their leaves. Here again the exact action is not, to my knowledge, understood. The following may be the explanation: It is well known that plants growing on the seacoast, in soil saturated with the salty sea water, are, in some respects, under almost the same conditions as in deserts, having great difficulty in obtaining sufficient water, though surrounded by water. The root hairs have difficulty in extracting the water from the strong salty solutions. The plants thus have various devices to prevent excessive evaporation or transpiration of water from the leaves, similar to those developed by desert plants. The injurious effect of the nitrogen salts may in this case be caused by simply producing such a strong solution of the salt in the vicinity of the plant that the roots are not able to absorb the necessary moisture, and thus the plant is compelled to cut off its leaves to prevent the transpiration of the water which can not be replenished by further absorption.

Sulphate of ammonia has been very widely used among orange growers. Nitrate of soda has been but little used thus far, but is apparently growing in favor. Its insecticide and water-attracting properties are probably much greater than those of sulphate of ammonia.

POTASH FERTILIZERS.

In fertilizing the orange, potash is most frequently used either in the form of the sulphate or of wood ashes. While sulphate of potash has been most widely used, there is apparently little evidence that it is in any way superior to other forms. Muriate of potash, containing the equivalent of about 50 per cent of actual potash, the form probably most used in the apple and peach orchards of the North, has been little used in orange groves. Apparently those who have used this form have obtained uniformly good results. Kainit, or German potash salt,

which is a crude double salt of magnesium sulphate with calcium chloride, containing the equivalent of from 12 to 14 per cent of actual potash, is a form much used in Northern orchards and is promising for use in orange groves. Its very active effect in increasing the surface tension of the soil moisture and thus attracting water to the trees, might make it an excellent form to add in early spring to aid the plant in withstanding the spring drought, which is so frequently injurious to the orange tree, and sometimes fatal to the fruit crop. Growers not supplied with facilities for irrigation would, undoubtedly find it profitable to consider carefully points of this nature in fertilization. The noticeable effect of potash on the orange tree appears to be its aid in completing and maturing the wood. Apparently an insufficient amount of potash is shown by an excessive growth of weak, immature wood, which does not harden up as winter approaches and is liable to be injured by frost.

An abundance of potash, in the form of sulphate of potash or tobacco stems, is said by many growers to produce excessively sour fruit. That potash is very necessary in fruit production is shown by the fact that the fruit contains a large percentage of this element. An average of fifteen analyses of different varieties of Florida oranges shows 52.05 per cent to be about the usual amount of potash in the ash of the orange fruit. The ash in these fifteen analyses averaged 0.916 per cent, or less than 1 per cent of the total weight of the fruit.

PHOSPHORIC ACID.

Phosphoric acid, which is a very necessary element of fertilization on Florida orange lands, is mostly used in the form of dissolved boneblack, acidulated bone or phosphate rock, soft phosphate, raw bone, guano, etc. The immediate effect of phosphoric acid on the orange tree and fruit is little understood. Several intelligent growers claim to be able to recognize the effect of phosphorous starvation by the appearance of the new growth of leaves. If these, when they first push out or while they are still young and tender, present a slightly variegated appearance, mottled with light and dark green, it is claimed that they are suffering from lack of phosphorus, and that if a liberal application of some soluble phosphate is applied this appearance may be checked. If this can be shown to be true it will prove a valuable index to the available quantity of phosphoric acid in the soil. A similar appearance, may, however, appear in light cases of the so-called "frenching," a disease, or probably more properly a symptom of disease, which is not uncommon. Phosphorous starvation, it is true, may have some effect in inducing this disease.

LIME.

Lime, it is usually supposed, is present in sufficient quantities in most of our soils. It may be questioned, however, whether the common high pine land and scrub land, and indeed much of the flat woods and ham-

mock of the interior of Florida, might not be benefited by dressings of lime. From the superiority of oranges grown on soils which are known to be rich in lime it would seem that this is probably a very desirable and necessary element for the production of superior fruit. The fine, smooth-skinned, and deliciously flavored Indian and Halifax River oranges, with their characteristic aroma, are grown largely on soils rich in lime from shell mounds and coralline and coquina rock. The oranges produced in the noted Orange Bend Hammock, which are of distinctive quality, with delicate, rich aroma, and thin, smooth rind, are produced on a soil underlaid by a marl rich in lime. Lime soils are in many orange countries considered superior for orange growing. Dr. A. Stutzer, in his work on the Fertilization of Tropical Cultivated Plants, writes: "The orange and citron fruits desire a deep, porous, dry soil, rich in lime. If sufficient lime is not present the fruit will be thick-skinned and not have a fine aroma." It appears also that the effect of abundant lime is to hasten to some extent the time of ripening. Fruits grown on soils rich in lime appear to color and become suitable for shipping some-

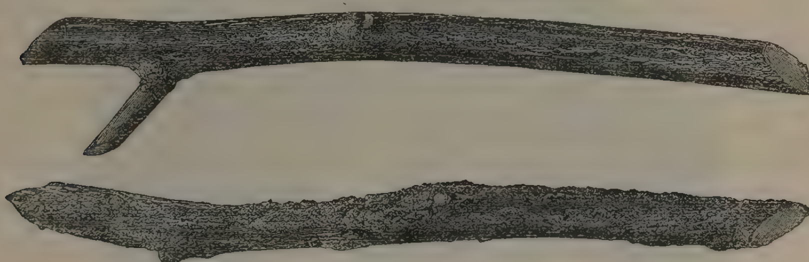

FIG. 18.—Orange twigs showing effects of die-back.

what earlier than those grown on soils containing but little lime. To secure a good quality of fruit the regular application of lime may be found very desirable in many groves.

FERTILIZATION AS AFFECTING DISEASE.

Probably the most common cause of injury to orange trees is a lack of fertilization, yet it is not infrequent for disease to be induced or aggravated by excessive or improper fertilization. This may, indeed, be of much more importance than we are at present inclined to believe. One of the forms of die-back, a common and destructive disease of the orange, is quite evidently due to errors in fertilization. In other cases the disease appears to be caused by planting in improper soil.

DIE-BACK.

Die-back manifests itself by a number of striking characters. The foliage becomes very dark green, the vigorous growth remains angular and immature and frequently becomes strongly recurved, and the tips turn up slightly, forming S-shaped curves. In the spring trees affected

with this disease start out a very vigorous growth, which may continue for several months. Finally a reddish brown resinous substance exudes on the twigs, forming the so-called die-back stain, which is very characteristic, and they begin to die back. This death of tissues may include the entire new growth or only a portion of it. Under the bark of the young limbs gum pockets form and burst out, causing large, unsightly eruptions on the twigs, as shown in figure 18.

Larger gum pockets frequently form at the nodes, producing large swellings. If a tree is badly affected no fruit is formed; if moderately affected an abundance of fruit sets, but the larger portion of this turns to a lemon-yellow color before half grown, becomes stained by the

FIG. 19.—Orange fruit showing effects of die-back.

characteristic reddish exudations like that occurring on the branches, and prematurely falls. Fruit which hangs on the tree till nearly ripe is large and coarse and is frequently stained. It usually splits and falls before thoroughly ripe. The fruit on a slightly affected tree is very large and coarse, with very thick, rough rind. Much of it is rendered unsalable by the reddish die-back stain. It is very prone to split and fall before mature. A split fruit of this character, showing also the die-back stain, is illustrated in figure 19.

Frenching, or variegation of the foliage, frequently accompanies die-back and seems to be a symptom of the disease. The very dark green coloration which some growers believe to be an indication of a healthy grove, may, on the contrary, denote a condition verging on die-back. A lighter green would probably indicate better general health.

DIE-BACK A DISEASE OF INDIGESTION.

Die-back appears to be a form of indigestion, due to an overfed condition of the plant. It occurs apparently wherever excessive quantities of nitrogenous manures from organic sources are applied or become available to the plant. Trees near closets or barns or in barnyards almost invariably have die-back. When chickens roost on a tree for any length of time, so that the droppings fall on the soil beneath, the disease usually results. Many cases are known to the writer where it has apparently been caused by excessive applications of cotton-seed meal, blood and bone, barn manure, etc. Indeed, all organic manures in excessive quantities appear to give rise to it. If organic fertilizers are used they must therefore be applied with considerable caution to avoid an excess. No safe rule can be given as to the amount of manure that can be used with safety; this depends upon the size and condition of the tree, previous treatment, and soil conditions.

Whether the chemical manures, nitrate of soda and sulphate of ammonia, will produce the disease if used in excessive quantities, is questionable. We have not been able to learn of any instance where this has occurred. Several cases are known where nitrate of soda was used of sufficient strength to cause the leaves to fall without producing any sign of this disease. Frequently the method of cultivation has considerable to do in causing die-back, excessive cultivation appearing to aggravate it very greatly.

MAL-DI-GOMMA.

The much-dreaded disease of foot rot, or mal-di-gomma, is probably not produced primarily by improper methods of fertilization, but seems to be considerably affected by the use of fertilizers and methods of cultivation. Groves in which cow-penning[1] has been practiced to a considerable extent are frequently affected with foot rot. This is so generally the case as to admit little doubt that this practice has considerable to do in inducing the disease. The extensive application of organic manures appears also to aggravate the malady to some extent, and their use in infected groves should be discouraged.

INSECT DISEASES.

With regard to the effect of fertilization upon insects which infest the orange, it may be said that the question is little understood. A general impression exists among the growers of the State that groves fertilized with blood and bone or barn manure are more liable to be badly infested with injurious insects than those fertilized exclusively with chemical manures. This appears to be especially true in the case of the six-spotted mite (*Tetranychus 6-maculatus*) and the purple scale

[1] A term used to designate the practice of penning cattle in orange groves over night, using a movable pen, the position of which is changed every few days.

(*Mytilaspis citricola*); judging from observations on many groves which have been fertilized with chemical manures only, it certainly seems that this belief is well founded. There is some evidence that the muriate of potash aids to some extent in preventing the ravages of the rust mite. Dr. Smith, of the New Jersey Agricultural Experiment Station, has found nitrate of soda and kainit to be very active insecticidal fertilizers. These have not been used to any extent in fertilizing orange groves in Florida, and no data have been obtained as to their effect on orange insects. It is probable that they would prove more effective than sulphate of ammonia or sulphate and muriate of potash, and they should be thoroughly tested to determine their value as fertilizers for the orange.

SUMMARY.

Summarizing, it may be said:

(1) By a proper combination of the various elements used in fertilization one can undoubtedly largely govern the quality and flavor of the fruit.

(2) To obtain a fruit with thin rind, use nitrogen from inorganic sources in moderate quantities, with considerable potash and lime.

(3) To sweeten the fruit, use sulphate of ammonia in considerable abundance, decreasing the amount of potash.

(4) To render the fruit more acid, increase the amount of potash and use nitrogen from organic sources.

(5) If it is desired to increase the size of the fruit, as is sometimes the case, apply a comparatively heavy dressing of nitrogen in some organic form and slightly decrease the other elements. In the case of the tangerine and mandarin, where a larger size is usually desired, a heavy dressing of nitrogen fertilizers would favor this end, and is not objectionable unless carried to excess.

(6) Fertilization has an important bearing on diseases.

(7) Die-back, a serious malady, is in all probability the result of overfeeding with nitrogenous manures from organic sources. These manures if used at all should be applied with great caution.

(8) Foot rot, although not primarily due to improper methods of fertilization, is no doubt considerably influenced by this cause.

(9) Insect diseases are also apparently influenced by the use of fertilizers, organic manures rendering the trees more liable to injury from this source than chemical fertilizers.

THE GEOGRAPHIC DISTRIBUTION OF ANIMALS AND PLANTS IN NORTH AMERICA.[1]

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IMPORTANCE OF A KNOWLEDGE OF THE GEOGRAPHIC DISTRIBUTION OF SPECIES.

An accurate knowledge of the areas which, by virtue of their climatic conditions, are fitted for the cultivation of particular crops is of such obvious importance to agriculture that the Division of Ornithology and Mammalogy was early led to make a special study of the geographic distribution of the land animals and plants of North America; for the boundaries of areas inhabited by native species were believed to coincide with those suited to the production of particular kinds of fruit, grain, and tubers, and for the rearing of particular breeds of domesticated animals.

When the boundaries of the life zones and areas are accurately mapped, the agriculturist need only ascertain the faunal area to which a particular crop or garden plant of limited range belongs in order to know beforehand just where it may be introduced with every prospect of success, soil and other local modifying influences being suitable; and, in the case of weeds and of injurious and beneficial mammals, birds, and insects, he would know what kinds were to be looked for in his immediate vicinity, and could prepare in advance for noxious species that from time to time suddenly extend their range. Persons living within the area likely to be invaded could escape by planting crops not affected, while those living outside might largely increase their revenues by giving special attention to the cultivation of the crops that are affected in the adjacent life zone.[2] In short, a knowledge of the

[1] A review of the work undertaken and of the results accomplished by the Division of Ornithology and Mammalogy.

[2] This prediction was made in the annual report of the Ornithologist for 1888 (pp. 482–483), and has been recently verified in a most gratifying manner. The distribution of certain noxious insects has been mapped by the Division of Entomology; the resulting areas conform to those of particular life zones as previously mapped by the Division of Ornithology. For instance, in writing of the San Jose orange scale insect, Mr. L. O. Howard states: "It may prove to be a significant fact that, although nursery stock affected by this scale has for six or seven years back been sent to all the fruit-growing regions of the Eastern States, according to our present information the scale has established itself only in regions contained within the so-called Austral life zone. Mapping the points of establishment, it is very interesting

natural life areas of the United States and of their distinctive species and crops would enable our farmers and fruit growers to select the products best adapted to their localities, would help them in their battle with harmful species, and would put an end to the present indiscriminate experimentation by which hundreds of thousands, if not millions, of dollars are needlessly expended each year.

The division has undertaken to furnish this information. When it began the study, ten years ago, little was known of the number or extent of the natural life areas of the country or of the laws limiting the dispersion of species. The faunal areas east of the Mississippi Valley had been recognized and in a general way defined, and attempts had been made to divide the country as a whole into areas of higher grade. Most zoological writers had agreed in apportioning the United States into three primary *provinces* or *regions*—an Eastern, reaching from the Atlantic to the Plains; a Central, from the eastern edge of the Plains to the Sierra Nevada and Cascade Range; and a Western or Pacific, from the latter to the Pacific Ocean—but botanical writers were at variance both as to the number and boundaries of the divisions they sought to establish. The division began by collecting all available data on the distribution of North American mammals and birds. The facts brought together were platted on maps as the first step in the investigation.

AN EXPERIMENTAL BIOLOGICAL SURVEY.

It soon became apparent, however, that in order to gain a clear conception of the facts and phenomena of distribution a careful study of the subject must be made in the field, where the actual range of mammals, birds, reptiles, insects, and plants could be ascertained and the distinctive areas contrasted. With this object in view, and with the sanction and approval of the Hon. J. M. Rusk, Secretary of Agriculture, and the Hon. Edwin Willits, Assistant Secretary, an experimental biological survey was made in the summer of 1889. The area selected was the San Francisco Mountain region in Arizona, which, because of its isolation, altitude, southern position, and proximity to an arid desert, was believed to offer unusual facilities for a successful study of the problems involved. That this expectation was more than realized

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to see how accurately this distribution has been followed. * * * This fact will relieve New England fruit growers north of southern Connecticut; those inhabiting the greater portion of Pennsylvania, except in the southeastern one-fifth and a western strip; those in New York, except for the strip up the Hudson River, and the loop which comes in from the northwest and includes the counties bordering Lake Ontario on the south, as well as those inhabiting the northern portion of the lower peninsula of Michigan and all of northern Wisconsin, from any fear of this insect. Such a condition of affairs would seem almost too good to be true, but the possibility of its truth is suggested by what we know up to the present time." (Insect Life, VII, No. 4, March, 1895, p. 292.)

may be seen by reference to the report of the expedition.[1] The area of which a careful survey was made comprises about 5,000 square miles, and enough additional territory was examined to make in all nearly 12,000 square miles, of which a biological map was published.

One result of this first survey was the complete overthrow of the principal faunal areas previously recognized in the United States, and a radical change in our conception of the principles involved. In ascending the mountain a succession of climatic belts were traversed, similar to those encountered in journeying northward from the Southern States to the polar sea, and each belt was found to be inhabited by a distinctive set of animals and plants.

The more important results of the survey may be briefly summarized as follows:

(1) It was demonstrated that terrestrial mammals, birds, reptiles, insects, and plants coincide in distribution, so that a map showing the boundaries of an area inhabited by an association of species in one group serves equally well for the other groups.

(2) Seven distinct belts or zones of animal and plant life were recognized between the Desert of the Little Colorado and the summit of San Francisco Mountain: A Desert area, a Piñon belt, a Pine belt, a Canadian belt, a Hudsonian belt, a Timber-line belt (afterwards merged with the Hudsonian as a subdivision), and an Arctic-Alpine area. No attempt was then made to propose a system of nomenclature for these several zones, but the important fact was recognized that they should be classed in two principal categories, a northern or Boreal, and a southern or Sonoran. The Alpine, Timber-line, Hudsonian, and Canadian were referred to the Boreal, while the Pine, Piñon, and Desert were referred to the Sonoran.

(3) On comparing the principal facts of distribution on this mountain with corresponding facts over the country at large, three important truths became apparent: (*a*) That the several life zones of the mountain could be correlated with corresponding zones long recognized in the eastern United States; (*b*) that these same zones are really of transcontinental extent, though never before recognized in the West; and (*c*) that the faunas and floras of North America as a whole, and, for that matter, of the Northern Hemisphere north of the tropical region, are properly divisible into but two primary life regions, a northern or Boreal, and a southern or Austral (then termed Sonoran), both stretching across the continent from ocean to ocean.

The report of the expedition was accompanied by colored maps showing in detail the geographic and vertical distribution of animals and plants on the mountain, and also by a colored provisional biological map of North America showing the general facts of distribution then available, arranged in accordance with the principles discovered in studying the San Francisco Mountain region.

[1] Results of a Biological Survey of the San Francisco Mountain Region in Arizona. North American Fauna, No. 3, September, 1890.

The results of this experimental biological survey were so important and far reaching as to completely revolutionize current notions of distribution. It was perceived that the Austral as well as the Boreal elements in the fauna and flora are distributed in transcontinental belts; hence the arbitrary and irrational division of the United States into Eastern, Central, and Western "provinces" gave way before a rational system, based on a knowledge of the actual facts of distribution, which were found to conform to the general principle of temperature control early recognized by Humboldt and others.

PROVISION FOR A SYSTEMATIC BIOLOGICAL SURVEY.

Since the primary object of mapping the geographic distribution of species is to ascertain the number, positions, and boundaries of the natural life areas—areas fitted by nature for particular agricultural productions—the practical importance of the subject outweighed, if possible, its scientific interest. This was clearly set forth in the annual report of the division for 1889, and Congress was urgently recommended to enlarge the scope of the work so that the division might carry on a systematic biological survey. The work on distribution had been previously restricted to a study of mammals and birds. In compliance with this recommendation, the restriction was removed by Congress, and in 1890 the division was authorized to undertake a comprehensive investigation of the geographic distribution of animals and plants. Congress having thus in effect established a biological survey, the task of mapping the distribution of species and ascertaining the boundaries of the natural life zones was given greater prominence and has been pushed as rapidly as the means at hand permitted.

In 1890 a biological reconnoissance was made of south-central Idaho, the area covered comprising about 20,000 square miles. The zones recognized were the same as in the San Francisco Mountain Survey, except that the lowermost was absent. In the report on this expedition[1] the courses of the several zones were described and the characteristic species of animals and plants enumerated. The *Pine* or *Neutral Zone* of the San Francisco Mountain Survey was named the *Transition Zone*, and the upper division of the Sonoran was formally recognized as the *Upper Sonoran Zone*.

THE DEATH VALLEY EXPEDITION.

In 1891 the most comprehensive and thorough biological survey ever undertaken was made by the division. An area embracing 100,000 square miles, stretching from the Pacific Coast to the one hundred and thirteenth meridian and from latitude 34° to latitude 38°, was chosen as the field of operations.

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[1] Report on a Biological Reconnoissance of South-Central Idaho. North American Fauna, No. 5, July, 1891.

This area comprises the greater part of southern California and Nevada, southwestern Utah, and the northwestern corner of Arizona, thus including all of the torrid desert valleys and ranges between the Sierra Nevada and the Colorado Plateau. It embraces also the highest and lowest lands within the United States—from Death Valley, nearly 500 feet below the level of the sea, to the lofty snow-capped peaks of the high Sierra, culminating in Mount Whitney at an altitude of nearly 15,000 feet. The region was selected because of the exceptional advantages it offered for studying the distribution of animals and plants in relation to the effects of temperature and humidity at different altitudes. The close proximity of desert valleys and lofty mountains brings near together species which in a more level country are characteristic of widely remote regions. Thus, in one place on the east side of the Sierra all of the life zones of North America, from the table-land of Mexico to the polar sea, may be crossed in a distance of only 10 miles.

The expedition, which came to be known as the Death Valley expedition, determined the distinctive species of each zone, traced the courses of the several zones from California to the Colorado Plateau, and made large collections of the mammals, birds, reptiles, insects, and plants, which are now deposited in the United States National Museum. One of the special objects of the expedition, and one early accomplished, was the location of the northern boundary of the Lower Sonoran Zone, a matter of considerable importance, because it marks the northern limit of successful raisin production and of profitable cultivation of cotton and several "subtropical" fruits. The valleys and deserts of this zone were determined from a study of the native animals and plants, and were enumerated in the annual report of the division for the same year (1891).[1] The results of this biological survey fill three volumes, two of which have been published and distributed;[2] the third has not yet gone to press.

CORRELATION OF THE LIFE ZONES.

A sufficient body of facts had now been brought together to justify a more comprehensive treatment of the subject than had before been possible. Therefore, in the spring of 1892 the writer published an essay on "The geographic distribution of life in North America, with

[1] The valleys and deserts of the Lower Sonoran Zone in California, Nevada, and Utah are: In California, the San Joaquin Valley, the whole of the Mohave and Colorado deserts, the San Bernardino, San Gabriel, and Santa Ana valleys, and the coast region to the southward except the mountains, the southern end of Owens Valley, Saline, Salt Wells, Panamint, and Death valleys; in Nevada, the Amargosa Desert, Pahrump, Indian Springs, Vegas, Ivanpah, and Virgin valleys; and in Utah, the St. George or lower Santa Clara Valley. (Rept. Ornith. and Mam. for 1891, p. 270.)

[2] North American Fauna, No. 7, May, 1893; and Contributions from the United States National Herbarium, Vol. IV, November 29, 1893.

special reference to the mammalia."[1] In this essay the continuity of all the zones, Austral as well as Boreal, was clearly established, tables of distinctive species were published, and the actual courses of the zones were shown on a colored map—the author's second provisional biogeographic map of North America. The following statement was made respecting the affinities and transcontinental character of the several zones and areas:

> The time has now arrived when it is possible to correlate the Sonoran zones of the West with corresponding zones in the East, as was done two years ago in the case of the Boreal zones, and as was intimated in the case of the Neutral or Transition Zone. It can now be asserted with some confidence, not only that the Transition Zone of the West is the equivalent of the Alleghanian of the East, but also that the Upper Sonoran is the equivalent of the Carolinian and the Lower Sonoran of the Austroriparian, and that each can be traced completely across the continent. Thus all the major and minor zones that have been established in the East are found to be uninterruptedly continuous with corresponding zones in the West, though their courses are often tortuous, following the lines of equal temperature during the season of reproduction, which lines conform in a general way to the contours of altitude, rising with increased base level and falling with increased latitude.

The zones were segregated into the two great transcontinental regions—Boreal and Sonoran[2]—that had been recognized two years previously, except that the Transition Zone was allowed to stand between the two without being referred to either. This latter action was criticised on the ground that it was illogical to interpose a belt of minor rank between two major regions, although it was conceded that the belt was one in which northern and southern types overlap. At the same time its affinities with the Austral seemed closer than with the Boreal, and it was afterwards allowed to go with the former, as its northernmost subdivision. The arid and humid subdivisions of all of the southern or Austral zones were recognized and shown on the map.

RECENT FIELD WORK.

In 1892 the northern boundary of the Lower Sonoran Zone was traced from New Mexico eastward across Texas, Indian Territory, and Arkansas to the Mississippi River, and sporadic field work was done in other States.

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[1]Presidential address before the Biological Society of Washington, delivered February 6, 1892. <Proc. Biol. Soc. Wash., Vol. VII, April, 1892, pp. 1–64, with colored map.

[2]The term "*Sonoran*" was still used for the Austral element in the fauna and flora which enters the United States from the table-land of Mexico, to avoid the introduction of a new name, the consideration of the nomenclature of the zones and regions being purposely deferred. The next year, however, the term "*Austral*" was formally used for this region, and the term "Sonoran" was restricted to its arid or western division. The first public use of the word "Austral" in the sense of a primary life region, was on the models and maps accompanying the exhibit of the Division of Ornithology at the World's Fair at Chicago in May, 1893, and in the annual report of the division for the same year (p. 228).

In 1893 a biological reconnoissance was made of Wyoming, a large part of which was found to be from 1,000 to 3,000 feet lower than represented on current maps, and consequently to have a warmer summer climate than was supposed, and to belong to the Upper Sonoran instead of the Transition Zone. The Wind River and Big Horn basins and the plains east of the Big Horn Mountains were found to be Upper Sonoran. Other work was done on the Great Plains in Kansas, Nebraska, and the Dakotas, and also in Utah, and on the table-land of Mexico.

During the year now drawing to a close (1894) a biological reconnoissance was made of the larger part of Montana, with special reference to the determination of the boundary between the Upper Sonoran and Transition zones. Other work was done in South Dakota and in the plateau region of Arizona. In the latter region two sections were run from the plateau southward to the Lower Sonoran deserts.

THE SEVEN LIFE ZONES OF NORTH AMERICA.

In the annual report of this division for 1893 the seven life zones of North America, including the tropical, were characterized with special reference to eastern North America, and some of the more important crops adapted to each were mentioned. Beginning at the north, these zones may be described as follows:

(1) *The Arctic or Arctic-Alpine Zone* lies above the limit of tree growth, and is characterized by such plants as the Arctic poppy, dwarf willow, and various saxifrages and gentians. The snow bunting, snowy owl, white ptarmigan, polar bear, arctic fox, and barren-ground caribou or reindeer are characteristic animals. The zone is of no agricultural importance.

(2) *The Hudsonian Zone* comprises the northern or higher parts of the great transcontinental coniferous forest—a forest of spruces and firs, stretching from Labrador to Alaska. It is inhabited by the wolverine, woodland caribou, moose, great northern shrike, pine bullfinch, white-winged crossbill, white-crowned sparrow, and fox sparrow. Like the preceding, this zone is of no agricultural importance.

(3) *The Canadian Zone* comprises the southern or lower part of the great transcontinental coniferous forest. It comes into the United States from Canada and covers the northern parts of Michigan, Vermont, New Hampshire, and Maine. Farther south it is restricted to the summits of the higher Alleghanies. Among the characteristic mammals and birds are the porcupine, varying hare, red squirrel, white-throated sparrow, and yellow-rumped warbler. Counting from the north, this zone is the first of any agricultural consequence. Here white potatoes, turnips, beets, the Oldberg apple, and the more hardy cereals may be cultivated with moderate success.

(4) *The Transition Zone* is the belt in which Boreal and Austral elements overlap. It covers the greater part of New England, New York, Pennsylvania, Wisconsin, and southern Michigan, and pushes

south along the Alleghanies to extreme northern Georgia. Here the oak, hickory, chestnut, and walnut of the south meet the maple, beech, birch, and hemlock of the north. The same overlapping is found among the mammals and birds, for the southern mole and cottontail rabbit,

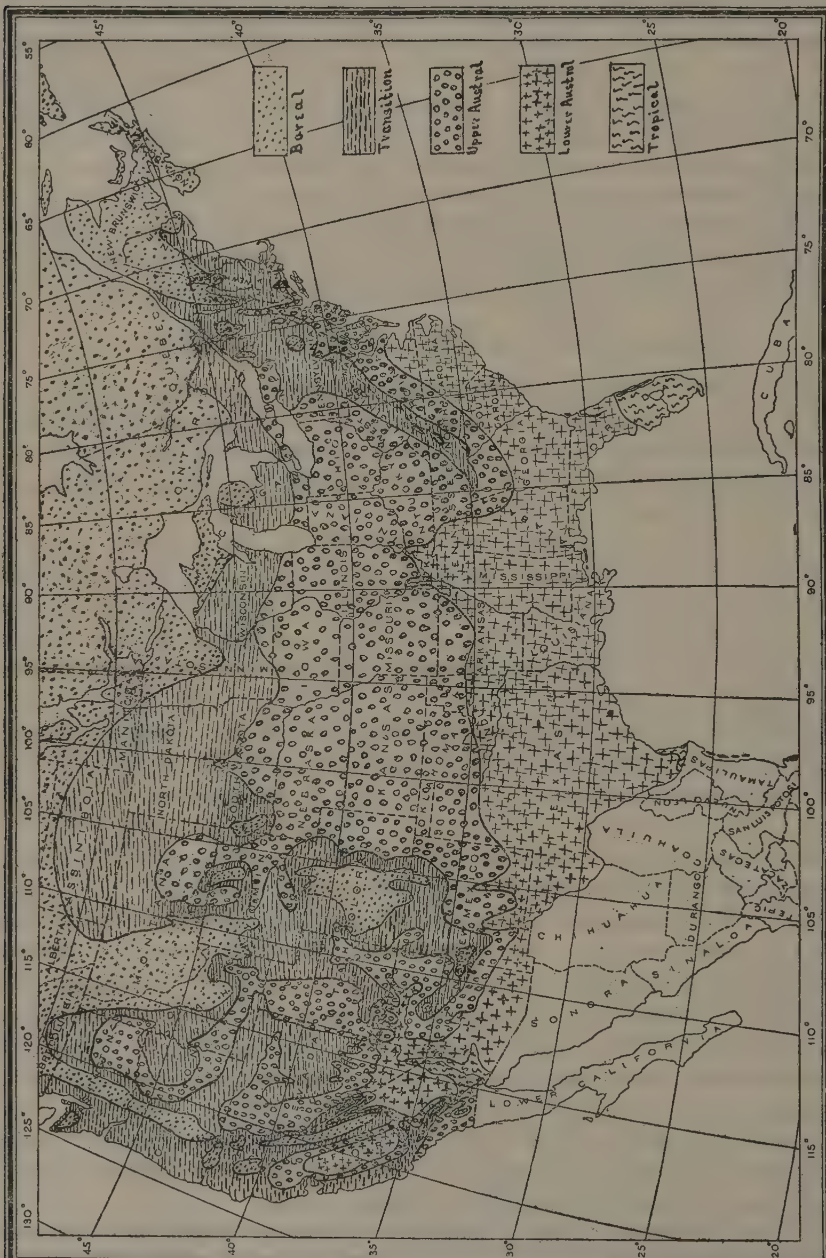

Fig. 20.—Map showing life zones of the United States.

the oriole, bluebird, catbird, thrasher, chewink, and wood thrush live in or near the haunts of the hermit and Wilson's thrushes, solitary vireo, bobolink, red squirrel, jumping mouse, chipmunk, and star-nosed

mole. In this zone we enter the true agricultural part of our country, where apples (Oldberg, Baldwin, Greening, wealthy, seek-no-farther, and others), blue plums, cherries, white potatoes, barley, and oats attain their highest perfection.

(5) *The Carolinian Zone* covers the larger part of the Middle States except the mountains; on the Atlantic coast it reaches from near the mouth of Chesapeake Bay to southern Connecticut, and pushes still farther north in the valleys of the Hudson and Connecticut rivers. It is the region in which the sassafras, tulip tree, hackberry, sweet gum, and persimmon first make their appearance, together with the opossum, gray fox, fox squirrel, cardinal bird, Carolina wren, tufted tit, gnat-catcher, and yellow-breasted chat. In this zone the Ben Davis and wine-sap apples, the peach, apricot, quince, sweet potato, tobacco, and the hardier grapes (such as the Concord, Catawba, and Isabella) thrive best.

(6) *The Austroriparian Zone* covers the greater part of the South Atlantic and Gulf States, beginning at the mouth of Chesapeake Bay. The long-leafed pine, magnolia, and live oak are common on uplands, and the bald cypress and cane in swamps. Here the mocking bird, painted bunting, red-cockaded woodpecker, and chuck-wills-widow are characteristic birds, and the cotton rats, rice-field rats, wood rats, little spotted skunks, and free-tailed bats are common mammals. This is the zone of the cotton plant, sugar cane, rice, pecan, and peanut; of the oriental pears (Le Conte and Kieffer), the Scuppernong grape, and of the citrus fruits—the orange, lemon, lime, and shaddock. In its western continuation (the Lower Sonoran) the raisin grape, olive, and almond are among the most important agricultural products, and the fig ripens several crops each year.

(7) *The Tropical Region*, within the United States, is restricted to southern Florida, extreme southeast Texas (along the lower Rio Grande and Gulf coast), and the valley of the lower Colorado River in Arizona and California. Among the tropical trees that grow in southern Florida are the royal palm, Jamaica dogwood, manchineel, mahogany, and mangrove; and among the birds may be mentioned the white-crowned pigeon, Zenaida dove, quail doves, a Bahaman vireo, Bahama honey-creeper, and caracara eagle. The banana, cocoanut, date palm, pine-apple, mango, and cherimoyer thrive in this belt.

FUNDAMENTAL PRINCIPLES OF ANIMAL AND PLANT DISTRIBUTION.

It now remains to discuss the causes of distribution, or rather the causes, other than absolute geographical barriers, that restrict species to definite areas or belts.[1] The fact has been long recognized—since the time of Humboldt at least—that animals and plants are not universally distributed over the earth, but disappear along certain more or less definite lines, which lines indicate a change in temperature uncongenial

[1] By permission of the Hon. J. Sterling Morton, Secretary of Agriculture, a preliminary announcement of the "Laws of temperature control of the geographic distribution of terrestrial animals and plants" was published in the National Geographic Magazine, Vol. VI, December 29, 1894, pp. 229–238, illustrated by 3 colored maps.

to the species; but exactly what temperatures exert the controlling influence, and how they can be measured, have only recently been discovered. Until the past year the mistake was made of assembling all the temperature data in accordance with a single hypothetical law. Then a radically different plan was tried: The temperature data were platted in accordance with two widely different principles—one with reference to the northern, the other the southern, boundaries of the zones. This departure was suggested by a somewhat tardy recognition of the fundamental facts of distribution discovered in 1889, namely, that animals and plants are themselves distributed from two directions—Boreal species from the north, and Austral species from the south. It seemed reasonable to infer, therefore, that northward distribution should be governed by one set of temperatures, and southward distribution by another. The temperature selected as probably fixing the limit of northward distribution is the sum of effective heat for the entire season of growth and reproduction, for it has been proved experimentally and long recognized by phenologists that many species of plants require a definite sum total of heat in order to successfully perform the several vital functions of leafing, blossoming, and fruiting, and that such plants can not mature their seeds until a particular sum of heat is attained. Since plants are unaffected by temperatures below and immediately above the freezing point, a minimum of 6° C. or 43° F. was assumed to represent the inception of the period of physiological activity in spring, and hence was used as a starting point in adding the normal daily temperatures for the entire period in question. Beginning at 43° F., all mean daily temperatures in excess of this were added together, the end of the period in fall being the time when the temperature fell to the same initial point. In this way it became possible to ascertain the total quantity of heat required for each species experimented upon.

When the sums of the positive temperatures for a large number of localities in the United States were platted on a large scale map it was found that isotherms (lines showing an equal quantity of heat) could be drawn that correspond almost exactly with the northern boundaries of the several zones. In the case of the southern boundaries a greater difficulty was encountered, for no data had been published bearing on the temperature control of southward distribution. At the same time it seemed evident, from data previously collected by the division, that species are limited in their southward distribution by the mean temperature of a brief period during the hottest part of the summer. For experimental purposes the mean normal temperature of the hottest six consecutive weeks of summer was assumed to be the factor desired, and this temperature was platted for a large number of localities. Isotherms were then drawn which marked the southern boundaries of the several zones along the Atlantic coast, and it was found that in ranging westward these isotherms conformed throughout to the tortuous boundaries of the Boreal, Transition, and Upper Austral zones, previously mapped from a study of the actual distribution of animals and plants.

While it is not for a moment supposed that the subject has been disposed of in all its details, it is confidently believed that the principles controlling the geographic distribution of terrestrial animals and plants have been discovered and that they may be expressed as follows:

In *northward* distribution terrestrial animals and plants are restricted by the sum of the positive temperatures for the entire season of growth and reproduction.

In *southward* distribution they are restricted by the mean temperature of a brief period during the hottest part of the year.

It is believed that these two principles cover the fundamental facts of distribution.

RECAPITULATION.

When the division undertook the study of the geographic distribution of life in North America, the transcontinental or zonary character of the principal life areas was not recognized, and the laws governing distribution were unknown. Zoologists and botanists had always worked independently; the maps each had published differed radically among themselves, and no agreement could be found between the two series. The divisions commonly adopted by zoologists were three—an Eastern, a Central, and a Western or Pacific province or region. In addition to these, some authors had recognized a transcontinental Boreal region, which was clearly shown on a map published by Dr. A. S. Packard in 1878.[1]

The first biological survey undertaken by the division (in 1889) established the important facts that the same laws govern the distribution of both animals and plants, and that the resulting areas of distribution are essentially coincident. It showed also that the life areas of North America and of the Northern Hemisphere as a whole take the form of a definite number of circumpolar or transcontinental belts, and that these belts or zones naturally arrange themselves in two principal categories or regions—a northern or Boreal and a southern or Austral.

The work accomplished by the division up to the present time may be briefly summarized as follows: The continent of North America has been divided into three primary life regions—Boreal, Austral, and Tropical—each of transcontinental extent. Their boundaries are sinuous, conforming to the distribution of temperature.

The *Boreal Region* stretches from Nova Scotia and Newfoundland westward to the Pacific Ocean, and from northern New England and the Great Lakes northward to the pole and southward over the prin-

[1] Dr. Packard's map was a decided advance over those of his predecessors, inasmuch as it showed the Boreal region to extend southward over the three great mountain systems of the United States—the Alleghanies, Rocky Mountains, and Sierra-Cascade. The remainder of North America, as shown on Dr. Packard's map, was divided between the three commonly recognized regions above mentioned—the eastern, central, and western or Pacific—to which were added on the south a Central American region and an Antillean region.

cipal mountains of the United States and Mexico. It is subdivided into three principal belts or zones, Arctic, Hudsonian, and Canadian. (1) The Arctic or Arctic-Alpine belt comprises Arctic America above the limit of tree growth, including Greenland and a narrow strip along the coast of Labrador and Newfoundland, and also the summits of the higher mountains above timber line throughout the United States and Mexico; (2) the Hudsonian Zone embraces the northern half of the great coniferous forest that reaches across the continent from Labrador to Alaska; (3) the Canadian Zone embraces the southern half of the great coniferous forest, stretching westward from northern New England and Nova Scotia to British Columbia.

The *Austral Region* is likewise subdivided into three transcontinental zones: (1) A Transition Zone; (2) an Upper Austral Zone; (3) a Lower Austral Zone, all stretching from the Atlantic to the Pacific and winding about sufficiently to cover areas of equal temperature. Each of the three Austral belts may be subdivided in an east and west direction into two or more areas, some of which are based on humidity instead of temperature. The eastern ends of these three belts have been long recognized by zoologists, and are known as the Alleghanian, Carolinian, and Austroriparian faunas. It was early shown by the division that the Austroriparian is the direct continuation of the arid Lower Sonoran fauna of the table-land of Mexico and the southwestern United States, and that this same faunal belt occupies the interior valley of California and most of the peninsula of Lower California.

The *Tropical Region* comprises Central America, the greater part of the coastal lowlands of Mexico, and the Antilles. It enters the United States at three points, southern Florida, the lower Rio Grande region in Texas, and the valley of the lower Colorado River in western Arizona and southeastern California.

The various zones have been studied in the field by the division and their boundaries located and mapped over extensive areas.

Summary.—The principles of geographic distribution of terrestrial animals and plants in the Northern Hemisphere were clearly recognized in 1889; the correlation of the life zones was completed in 1892; the laws of temperature control were formulated in 1894. The work remaining undone relates to details and may be classed under four heads: (1) Completion of the boundary surveys of the several zones; (2) subdivision of the zones into minor faunas and floras; (3) tabulation of the distinctive species of each zone and its subdivisions; (4) formulation of the subordinate laws governing the restriction of species to particular areas within the principal zones.

It appears, therefore, that in its broader aspects the study of the geographic distribution of life in North America is completed. The primary regions and their principal subdivisions have been defined and mapped, the problems involved in the control of distribution have been solved, and the laws themselves have been formulated.

HAWKS AND OWLS AS RELATED TO THE FARMER.

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CAUSE OF THE PREJUDICE AGAINST BIRDS OF PREY.

The old saying that "a little knowledge is a dangerous thing" is exemplified in the way our hawks and owls are looked upon by a large majority of mankind. The farmer sees a hawk strike a fowl which has wandered from the farmyard; the sportsman, while planning the capture of a covey of quail, finds the mutilated remains of a game bird and feels sure it is the unlawful prey of a thieving owl—without further investigation both men condemn birds of prey as a class, and lose no opportunity to destroy them and their eggs and young.

The ill feeling has become so deep rooted that it is instinctive even in those who have never seen any depredations. How are we to account for this hatred against birds of prey by the class of men who should be the first to clamor for their protection? The prejudice is largely due to lack of discrimination. Since they know that hawks and owls attack poultry, they do not stop to think that these depredations may be made by a few species only, but make a sweeping condemnation of the whole family. The reasoning is much the same as that of an Indian or frontiersman, who, being wronged by one individual, condemns a whole race. It would be just as rational to take the standard for the human race from highwaymen and pirates as to judge all hawks by the deeds of a few. Even when the industrious hawks are observed beating tirelessly back and forth over the harvest fields and meadows, or the owls are seen at dusk flying silently about the nurseries and orchards, busily engaged in hunting the voracious rodents which destroy alike the grain, produce, young trees, and eggs of birds, the curses of the majority of farmers and sportsmen go with them, and their total extinction would be welcomed. How often are the services rendered to man misunderstood through ignorance! The birds of prey, the majority of which labor day and night to destroy the enemies of the husbandman, are persecuted unceasingly, while that gigantic fraud—the house cat—is petted and fed and given a secure shelter from which it may emerge in the evening to spread destruction among the feathered tribe. The difference between the two can be summed up in a few words—only three or four birds of prey hunt birds when they can procure rodents for

food, while a cat seldom touches mice if she can procure birds or young poultry. A cat has been known to kill 20 young chickens in a day, which is more than most raptorial birds destroy in a lifetime.

It is to be lamented that the members of the legislative committees who draft the game laws of various States have not a better knowledge of the life histories of raptorial birds. It is surprising also that gun clubs should be so far behind the times as to offer prizes to those who kill the greatest number of birds of prey; for in clubs of any importance, there must be naturalists whose counsel ought to prevent such barbarity. That the beneficial species of hawks and owls will eventually be protected there is not the slightest doubt, for when the farmer is convinced that they are his friends he will demand their protection; and already the leading agricultural papers and sportsman's journals are deprecating their indiscriminate slaughter.

SOME CHARACTERISTICS OF RAPACIOUS BIRDS.

The rapacious birds are slow breeders, rearing only one brood a year, though of course if the first set of eggs is destroyed another will be deposited. The young grow slowly and need a relatively large amount of food to develop properly. To satisfy their enormous appetite requires constant foraging on the part of the parents, and the strain of bringing up the family is probably twice that of any of the other land birds. Even the adults are large eaters, gorging to the utmost when the opportunity presents; and as digestion is very rapid and assimilation perfect, a great quantity of food in relation to the body weight is consumed each day. Taking more food than necessary for immediate wants enables them to store up force for future emergencies, for they are often required to withstand great exposure and long-protracted fasts, especially during inclement weather.

Hawks and owls are complementary to each other. While hawks hunt by day and keep diurnal mammals in check, owls, whose eyesight is keenest during twilight and the early hours before dawn, capture nocturnal species which the former is not apt to obtain. Again, the owls are less migratory than the hawks, and during the long winter nights they remain in the land of ice and snow to wage incessant warfare against the little enemies of the orchard, garden, and harvest fields.

Although much may be learned about the food from observing the habits of the live birds, the only way to find out the full range and relative percentages of the food elements is by examination of the stomach contents. Sometimes, in the case of birds of prey, a moderately complete and reliable index to the food can be obtained by examining the "pellets." Hawks and owls often swallow their smaller victims entire and tear the larger ones into several pieces, swallowing each fragment as it is detached. After the nutritious portion of the food has been absorbed, the indigestible parts, such as hair, feathers, scales, bones, and other hard parts, are rolled into a solid ball by the

action of the muscles of the stomach. These masses, known as "pellets" are regurgitated before fresh food is taken. The movements of the stomach so shape the "pellets" that the sharp pieces of bone which might otherwise injure the mucous membrane are carefully enveloped in a felty covering of hair or feathers. The pellets contain everything necessary to identify the food, and in the case of some of the owls which have regular roosting places the vast number of pellets that collect underneath give an almost perfect record of the results of their hunting excursions.

FOOD HABITS OF THE PRINCIPAL BIRDS OF PREY.

It is the object of the present paper to review more or less briefly the food habits of the principal birds of prey of the United States, so that those who are most interested in the subject may be able to distinguish between enemies and friends, and hence be saved the humiliation of wronging the latter while endeavoring to destroy the former.

Hawks and owls may be divided arbitrarily into four classes, according to their beneficial and harmful qualities:

(1) Species which are wholly beneficial.

(2) Those chiefly beneficial.

(3) Those in which the beneficial and harmful qualities about balance.

(4) Harmful species.

It should be stated here that several of the species may belong to one or another class according to the locality they frequent. A hawk or owl may be locally injurious because at that place mice, squirrels, insects, and other noxious animals are scarce, and consequently the bird has to feed on things of more or less value to man, while in other regions where its favorite food is obtainable in sufficient quantity it does absolutely no harm. A good example of this kind is given under the head of the great horned owl in a subsequent part of this paper.

To the wholly beneficial class belong the large rough-legged hawk, its near relative, the squirrel hawk or ferruginous roughleg, and the four kites—the white-tailed kite, Mississippi kite, swallow-tailed kite, and everglade kite.

The chiefly beneficial class contains a majority of the hawks and owls, and includes the following species and their races: Marsh hawk, Harris's hawk, red-tailed hawk, red-shouldered hawk, short-tailed hawk, white-tailed hawk, Swainson's hawk, short-winged hawk, broad-winged hawk, Mexican black hawk, Mexican goshawk, sparrow hawk, Audubon's caracara, barn owl, long-eared owl, short-eared owl, great gray owl, barred owl, western owl, Richardson's owl, Acadian owl, screech owl, flammulated screech owl, snowy owl, hawk owl, burrowing owl, pygmy owl, ferruginous pygmy owl, and elf owl.

The class in which the harmful and beneficial qualities balance includes the golden eagle, bald eagle, pigeon hawk, Richardson's hawk, Aplomado falcon, prairie falcon, and great horned owl.

The harmful class comprises the gyrfalcons, duck hawk, sharp-shinned hawk, Cooper's hawk, and goshawk.

HARMLESS SPECIES OF HAWKS AND OWLS.

We will now take up each class and examine the species more or less in detail so as to show briefly the character of the food. The harmless species include the four kites, which, if not as beneficial as some of the hawks, are at least perfectly harmless. The *everglade kite* is found within our borders in Florida only, where it is restricted to the middle and southern portions. It feeds exclusively on a large fresh-water snail,

FIG. 21.—Swainson's Hawk (*Buteo swainsoni*).

which abounds in the shallow lakes and overflowed sections grown up with grass and other herbage. The swallow-tailed, Mississippi, and white-tailed kites feed largely upon reptiles and insects, and never as far as known attack birds. The *swallow-tailed* is reported as feeding quite extensively on the cotton worm during the summer and early fall. If this is a common habit, it brings the bird at once into prominence as of economic importance and of great value to the Southern planter. The *Mississippi kite* and its white-tailed ally devour large numbers of lizards, small snakes, and insects; of the latter, grasshoppers and beetles are most frequently taken.

WHOLLY BENEFICIAL HAWKS.

The *rough-legged hawk*, and the *ferruginous roughleg*, or *squirrel hawk*, as it is sometimes called on account of its great fondness for the ground squirrels so destructive in the West, are among our largest and at the same time the most beneficial hawks. The former breeds wholly north of the United States, migrating south in September and October and remaining until the following April. The latter breeds extensively through the Great Plains region. The winter range of the roughleg is determined more by the fall of snow than by the intensity of cold, the main body advancing and retreating as the barrier of snow melts or accumulates. Meadow mice and lemmings form the staple food of this bird. In this country the lemmings do not reach our territory except in Alaska, but in the north of Europe they occasionally form into vast, migrating, devastating hordes which carry destruction to all crops in the country passed over. The vole, or meadow mouse, is common in many parts of this country, and is, east of the Mississippi River, without doubt, the most destructive mammal to agriculture. It destroys meadows by tunneling under them and eating the roots of grass. In many meadows the runways form networks which extend in every direction, giving an idea of the animal's abundance. This mouse also destroys grain and various kinds of vegetables, especially tubers, but probably does even more damage by girdling young fruit trees. In 1892 considerable areas in southeastern Scotland were overrun by meadow mice and a large amount of property was destroyed during the "vole plague." Just such invasions might be expected in any country where predaceous mammals and birds are reduced to a minimum in the supposed interest of game preservation. This wholly upsets nature's balance, and the injurious rodents are left practically without an enemy to control their increase. We have little reason, however, to exult over the older country, for in many portions of the United States the people, if they had the power, would follow the same shortsighted policy, causing inestimable damage to the agriculturist. Attempts have been made in some States to reduce the number of hawks and owls by offering bounties for their heads, but fortunately the work has not been carried far enough to do the harm that has been done by the long-continued efforts of gamekeepers in Great Britain.

The *roughleg* is one of man's most important allies against meadow mice, feeding on little else during its six months' sojourn in the United States. It thus renders important service in checking the ravages of these small but formidable pests. The roughleg is somewhat crepuscular in habits, being on the alert during twilight and early dawn, when small mammals are most active. Other mice, rabbits, and ground-squirrels are taken occasionally, and some of the older writers state that waterfowl are captured by this bird. The writer has made careful inquiries of a considerable number of persons who have had extensive

field experience where these birds are common and in no instance has he heard of their attacking birds. Even better evidence is found in the fact that stomachs of specimens shot in locations teeming with waterfowl contained nothing but the remains of meadow mice.

The *ferruginous roughleg* is as fully beneficial as its relative, though the character of its food differs somewhat. In many parts of the country inhabited by it, the meadow mice which play such an important part in the economy of the other bird are scarce or wanting, but are replaced by nearly as destructive rodents, the ground squirrels. Upon these this large and handsome hawk wages a continuous warfare, and great is the service it performs in keeping their numbers in check. Rabbits, prairie dogs, and occasionally pouched gophers are eaten. It is humiliating to think how many of these two noble hawks are ruthlessly murdered, and to reflect that legislators put bounties on their heads to satisfy the ignorant prejudices of their constituents.

HAWKS AND OWLS MOSTLY BENEFICIAL.

Nearly two-thirds of the birds of prey inhabiting the United States belong in the second class, which comprises such hawks and owls as are mainly beneficial. A few of the most useful and well-known species will be considered in detail.

The *marsh hawk* is one of the most valuable in the class on account of its abundance, wide distribution, and peculiar habits. It is more or less common throughout the United States and may be easily recognized by its white rump, slender form, and long, narrow wings, as it beats untiringly over the meadows, marshes, and prairie lands in search of food. If it were not that it occasionally pounces upon small birds, game, and poultry, its place in the first class would be insured, for it is an indefatigable mouser. Rodents, such as meadow mice, rabbits, arboreal squirrels, and ground squirrels, are its favorite quarry. In parts of the West the latter animals form its chief sustenance. Lizards, snakes, frogs, and birds are also taken. Among the birds most often captured are the smaller ground-dwelling sparrows, of least use to the farmer.

From its abundance, wide distribution, and striking appearance, the *red-tailed hawk* is probably the best known of all the larger hawks. Since it is handicapped by the misleading name "hen hawk," its habits should be carefully examined. There is no denying that both it and the *red-shouldered hawk*, also known as "hen hawk," do occasionally eat poultry, but the quantity is so small in comparison with the vast numbers of destructive rodents consumed that it is hardly worth mentioning. While fully 66 per cent of the red-tail's food consists of injurious mammals, not more than 7 per cent consists of poultry, and it is probable that a large proportion of the poultry and game captured by it and the other buzzard hawks is made up of old, diseased, or otherwise disabled fowls. It is well known to poulterers and owners of game

preserves that killing off the diseased and enfeebled birds, and so preventing their interbreeding with the sound stock, keeps the yard and coveys in good condition and hinders the spread of fatal epidemics. It seems, therefore, that the birds of prey which catch aged, frost-bitten, and diseased poultry, together with wounded and crippled game, are serving both farmer and sportsman.

Abundant proof is at hand to show that the red-tail greatly prefers the smaller mammals, reptiles, and batrachians, taking little else when these can be obtained in sufficient numbers. If hard pressed by hunger, however, it will eat any form of life and will not reject even offal and carrion; dead crows from about the roosts, poultry which has been thrown on the compost heap, and flesh from the carcasses of goats, sheep, and the larger domesticated animals being eaten at such times. The immature birds are more apt to commit depredations, the reason probably being that they lack skill to procure a sufficient quantity of their staple food. A large proportion of the birds captured consists of ground-dwelling species, which are probably snatched up while half concealed in the grass or other vegetation. Among the mammals most often eaten and most injurious to mankind are the arboreal and ground squirrels, rabbits, voles and other mice. The stomachs of the red-tailed hawks examined contained Abert's squirrel, red squirrel, three species of gray squirrels, two species of chipmunks, Say's ground squirrel, plateau ground squirrel, Franklin's ground squirrel, striped ground squirrel, harvest mouse, common rat, house mouse, white-footed mouse, Sonoran white-footed mouse, wood rat, meadow mouse, pine mouse, Cooper's lemming mouse, cotton rat, jumping mouse, porcupine, jack rabbit, three races of cottontails, pouched gopher, kangaroo rat, skunk, mole, and four kinds of shrews. The larger insects, such as grasshoppers, crickets, and beetles, are sometimes extensively used as food.

The *red-shouldered hawk*, or, as it is sometimes incorrectly called, the "hen hawk," is a common bird, and a very valuable one to the farmer. It is more omnivorous than most of our birds of prey, and has been detected feeding on mice, birds, snakes, frogs, fish, grasshoppers, centipedes, spiders, crawfish, earthworms, and snails. As about 90 per cent of its food consists of injurious mammals and insects, and hardly 1½ per cent of poultry and game, the reader may draw his own conclusions as to the appropriateness of the title "hen hawk," so often misapplied to this species. A pair of these hawks bred for successive years within a few hundred yards of a poultry farm containing 800 young chickens and 400 ducks, and the owner never saw them attempt to catch a fowl. Besides mice, squirrels, shrews, and insects, which form their principal food, frogs, snakes, and crawfish are also taken.

Such facts as these must convince intelligent persons not only that it is folly to destroy this valuable bird, but that it should be everywhere fostered and protected.

The food of *Swainson's hawk* (fig. 21) is of much the same character as that of the two preceding species, except that more insects and fewer birds are taken. Soon after the breeding season the hawks collect in the foothills and on the plains of the West, forming flocks, some of which contain hundreds of individuals, and feed almost exclusively on grasshoppers and crickets. If we assume that 100 grasshoppers, which is only three-quarters of the number actually found in a stomach after a single meal, is the daily allowance for one hawk, we have a grand total of 900,000 for the work of a flock of 300 birds in one month. The weight of this vast number of insects, allowing 15.4 grains for the weight of each, amounts to 1,984 pounds. An average of a number of estimates given by entomologists places the quantity of food daily devoured by a grasshopper as equal to his own weight; consequently if these grasshoppers had been spared by the hawks the farmer would have lost in one month nearly 30 tons of produce. The above estimate is probably much too low; for each hawk doubtless eats at least 200 grasshoppers daily, which would double the amount, making the loss 60 tons instead of 30. This is the work of a month for only 300 hawks. What estimate can be placed on the services of the hundreds of thousands which are engaged in the same work for months at a time? In many places hawks are all that are left of the mighty army which once waged war against these insect pests and so kept them in check. The game birds, such as the wild turkey, prairie chicken, grouse, and quail, have been swept away by the ruthless hand of man, and even the skunks, foxes, and snakes are rapidly following. To make matters worse, at least one Western State passed a bounty act which paid for the destruction of hawks and owls, as a result of which thousands of grasshopper-eating hawks were destroyed at the public expense. Is it a wonder that after their enemies were reduced to a minimum the grasshoppers increased and spread destruction before them?

All naturalists who have written on the habits of Swainson's hawk affirm that it is a great enemy to the ground squirrel and other injurious rodents which infest the West and torment the farmer. The evidence shows that it rarely touches poultry, game, or small birds. In the Southwest the writer has often seen the nests of small birds in the same trees and in close proximity to the nests of the hawks, the birds apparently living in perfect harmony. Other observers have noticed the same thing.

The *broad-winged hawk*, a medium-sized species, common throughout the eastern United States, feeds largely on insects, small mammals, snakes, toads, and frogs, and occasionally on small birds. It is especially fond of the larvæ or caterpillars of the large moths which feed upon the leaves of fruit and shade trees. These insects are too large and formidable for the smaller insectivorous birds to attack; hence their principal enemies are the hawks, of which the one under consideration is the most important. It also feeds extensively upon grass-

hoppers, crickets, cicadæ, May beetles and other coleoptera. Like the other buzzard hawks (*Buteo*), it is fond of meadow mice, and also takes considerable numbers of chipmunks, shrews, red squirrels, and occasionally rabbits and moles. Probably the greatest damage done by this hawk is the destruction of toads and snakes, which are mainly insectivorous and hence beneficial to the farmer.

The *sparrow hawk*, which is found throughout the United States, is the smallest and handsomest of our birds of prey, and, with the possible exception of the red-tail, the best known. It is the only one of the true falcons which can be placed in the "mainly beneficial" class. At times it follows the example of its larger relatives and attacks small birds and young chickens, but these irregularities are so infrequent that they are more than outweighed by its usual good services in destroying insects and mice. Grasshoppers, crickets, and other insects form its principal food during the warm months, while mice predominate during the rest of the year. In localities where these insects are abundant it congregates, often in moderate-sized bands, and feeds almost continuously on them. Terrestrial caterpillars, beetles, and spiders are also eaten to a considerable extent. As might be expected, a very large proportion of the birds captured is taken while the hawks are busy hatching their eggs and rearing the young, thus having less time to procure their favorite food. It is also at this time that we hear complaints of their depredations in poultry yards. During the late fall and winter months the meadow mice and house mice form a large part of their food, the former being taken in the fields and meadows, and the latter around the corn stacks and about the barns and outbuildings. On account of the sparrow hawk's confidence and lack of fear, it is one of the species which suffers most from the unjust bounty laws. Any vandal who can carry a gun is able to slaughter this little hawk. Mr. W. B. Hall, of Wakeman, Ohio, writes us that while the hawk law was in force in Ohio he was township clerk in his native village and issued 86 certificates, 46 being for sparrow hawks. He examined the stomachs and found 45 of them to contain the remains of grasshoppers and beetles, while the remaining one contained the fur and bones of a meadow mouse. Mr. H. W. Henshaw, visiting Colorado in 1883, after the bounty act had been in force for some time, found that the sparrow hawks had been almost exterminated in districts where several years before he had found them exceedingly numerous.

It is a question whether the slightly harmful owls should not be placed among the wholly beneficial species, for the injury done in destroying birds and poultry is insignificant compared with their good work. The *barn owl* is a southern species, rarely occurring with regularity in the northern half of the United States except west of the Sierra Nevada. Its food is made up almost entirely of mammals, with now and then a few insects, and occasionally a bird. Among the former are several species of rodents which, from their great numbers

and destructive habits, are a curse to the country they inhabit. Of this group the pouched gopher is one of the most destructive, not only to vegetables and grain crops but also to shade and fruit trees. The injuries to trees are the most serious, as the animals sometimes gnaw off the roots and destroy entire groves and orchards. In California, where this mammal is common, the barn owl feeds very extensively on it. In the South Atlantic and Gulf States the owl feeds extensively on the cotton rat, a mammal of destructive habits found abundantly in the bottom lands and near water. The common rat is also greedily devoured. The writer has examined the contents of 200 pellets taken from the nesting site of a pair of these owls in one of the towers of the Smithsonian Institution. Of the total of 454 skulls contained in these pellets there were 225 meadow mice, 2 pine mice, 179 house mice, 20 rats, 6 jumping mice, 20 shrews, 1 starnosed mole, and 1 vesper sparrow. This examination gives a pretty complete index to the class of food taken by this species in the East, along the northern border of its range.

The *long-eared owl* is an industrious mouser, and molests comparatively few birds. Several years ago we examined 107 stomachs of this owl, of which 15 were empty. Of the 92 remaining, 86, or over 93 per cent, contained the remains of small mammals. As the bird occurs in suitable localities all over the United States and is one of the commonest owls, the good it does must be very great. Like the sparrow hawk, this owl is easily destroyed, and so is one of the greatest sufferers when laws are enacted for the destruction of birds of prey, and many a bounty has been paid for its head.

The *short-eared owl* is another common species, but is not so well distributed as the preceding. It is found in more open country, and in fall and winter often congregates in large bands about meadow lands and the larger marshes. Fully 75 per cent of its food consists of mice; as many as six of these mammals have been found in one stomach. It probably also feeds on the smaller ground squirrels in the West, but we have been unable to procure much positive data on the subject. Among birds, the sparrows inhabiting the meadows and prairies are most often taken. In an interesting article by Mr. Peter Adair, in the Annals of Scottish Natural History for October, 1893, on the disappearance of the short-tailed vole, which caused the vole plague in Scotland in 1890–1892, the statement is made that farmers and shepherds attribute its disappearance largely to the action of its natural enemies, stress being laid on the services of the owl, kestrel, rook, and black-headed gull among birds and the stoat and weasel among mammals. These men are also of the opinion that the recent vole plague is a result of the destruction of birds of prey. When the plague first commenced the short-eared owl was hardly known in the district, but, swarming thither, it bred till it was so numerous that it became an important factor in reducing the number of voles. In speaking of an enemy of the

RED-TAILED HAWK (BUTEO BOREALIS).

SPARROW HAWK (FALCO SPARVERIUS).

BARRED OWL (SYRNIUM NEBULOSUM).

owl, Mr. Adair recorded an interesting fact. A fox which had acquired a taste for lamb had to be disposed of. In the lair with its 5 young were found 76 dead short-eared owls, a number of grouse, black game, partridges, ducks, curlew, plover, rats, voles, and lambs. This was in May, and of this great number of owls 8 were adults and 68 were young. During a number of vole invasions of Great Britain in previous years short-eared owls had been observed to increase rapidly and do good work in destroying the pests.

The *barred owl* is one of the larger common species in eastern North America. It has the reputation, especially among the older writers, of being very destructive to poultry. Our examination of 100 stomachs shows that about 4½ per cent of its food consists of poultry and game. Half-grown fowls which roost among the trees and bushes away from the farmyards are the ones that suffer. If the chickens were shut up in the yard at night the owl would not be tempted to depart from its regular diet. The barred owl is more given to cannibalistic habits than any of the other species. Of 109 stomachs which passed under the writer's notice, 7 contained the remains of smaller owls. Numerous accounts of similar instances have appeared in various journals. Insects, such as grasshoppers, crickets, May beetles and other coleoptera, are frequently taken. In some localities crawfish form a considerable portion of this owl's food, and frogs and fish are occasionally taken. The majority of its food, however, consists of small mammals, among them some of the most destructive rodents the farmer has to contend with. The following list shows the species of mammals positively identified in the stomach contents: Meadow mouse, pine mouse, short-tailed shrew, chipmunk, red squirrel, flying squirrel, cottontail rabbit, golden mouse, white-footed mouse, red-backed mouse, common mole, Cooper's lemming mouse, and common rat. In summing up the facts relative to the food habits of this owl, it appears that although it occasionally makes inroads upon poultry and game, it destroys large numbers of injurious mammals and insects, and hence should occupy a place on the list of birds to be protected.

The little *screech owl* is well known throughout the greater part of the United States. With the exception of the *burrowing owl*, it feeds more extensively on insects than any of the other species. It is also a diligent mouser, and feeds more or less frequently on crawfish, frogs, toads, scorpions, lizards, and fish. Of 254 stomachs examined, birds were found in about 15 per cent. Fully one-third of these consisted of English sparrows, and a large proportion of the rest were ground-dwelling sparrows, which feed largely on seeds and are of little economic importance. Among insects, grasshoppers, crickets, beetles, and cutworms are most often eaten. As many as 50 grasshoppers have been found in one stomach, 18 May beetles in another, and 13 cutworms in a third. During the warmer parts of the year it is exceptional to find a stomach not well filled with insect remains. Meadow mice, white-

footed mice, and house mice are the mammals most often taken, while chipmunks, wood rats, flying squirrels, and moles are less frequently found. The screech owl is fond of fish and it apparently catches many, especially in winter. At this time it watches near the breathing holes in the ice, and seizes the luckless fish which comes to the surface. Most of the birds destroyed by this owl are killed either in severe winter weather or during the breeding season, when it has hard work to feed its young. As nearly three-fourths of the owl's food consists of injurious mammals and insects, and only about one-seventh of birds (a large proportion of which are destructive English sparrows), there is no question that this little owl should be carefully protected.

The *snowy owl* is a large arctic species which in winter occasionally occurs in considerable numbers in the United States. On account of

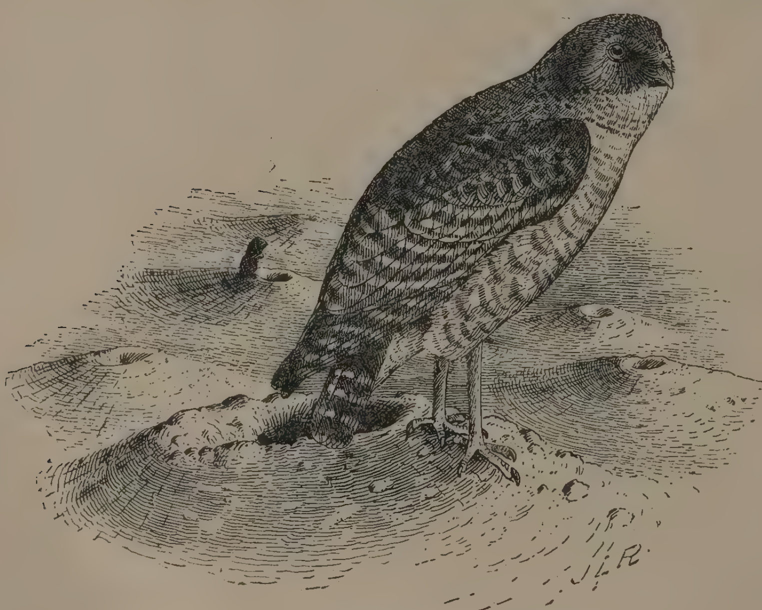

FIG. 22.—Burrowing Owl (*Speotyto cunicularia hypogœa*).

its large size it is capable of doing great good in destroying noxious mammals. The stomachs which we have examined were collected between the last of October and March, and make a very good showing for the bird. Although a number of water birds were found, a large proportion of the contents consisted of mammal remains. One stomach contained 14 white-footed mice and 3 meadow mice, and in others as many as 5 to 8 of these little rodents were found. The common rat occurred in a number of stomachs and appears to be considerably sought after. It is a lamentable fact that this useful bird is slaughtered in great numbers whenever it appears within our limits. According to Mr. Ruthven Deane, as many as 500 were killed in New England during the winter of 1876–77.

Although the little *burrowing owl* is preeminently an insect-eating bird, it also feeds on small mammals and rarely on birds. It is common throughout the plains of the West, where it is usually a permanent resident. During the warmer months it feeds almost exclusively on insects and scorpions, and at other times on small mammals. In regard to its habit of eating scorpions, Mr. George H. Wyman, of St. George, Utah, states, in Forest and Stream for March 3, 1887, that during the summer the owl comes quietly about the house at dusk and picks up the scorpions by scores. Usually it has a place near by where it retreats to eat such portions as are desired. It devours the soft parts of the scorpion, leaving the head, claws, and tail, until a quart or more of such remnants may be found at the place of banquet. Among insects, grasshoppers, crickets, beetles, and caterpillars are taken in large quantities, and the birds may be seen pursuing the more agile species even at midday. The burrowing owl (fig. 22) is a beautiful, harmless bird, and should be protected by law.

The golden eagle, bald eagle, pigeon hawk, Richardson's hawk, Aplomado falcon, prairie falcon, and great horned owl belong to the third class, which includes those whose beneficial and noxious qualities about balance each other. Still at times any one of them may become decidedly beneficial in localities infested by some of the numerous rodents which injure crops. The *golden eagle*, an inhabitant of the Northern Hemisphere, is found in most parts of the United States, though it is more common in the West. The food consists of game, such as fawns, rabbits, woodchucks, prairie dogs, and ground squirrels, among mammals, and turkeys, grouse, and waterfowl, among birds. At times it also troubles the young of domesticated animals, notably lambs, pigs, goats, and poultry. It has been known to attack calves and colts, but these instances must be exceptional and when the birds are hard pressed by hunger. Over extensive areas of the West the golden eagle and other birds of prey unite in keeping many species of noxious rodents in check, and must be considered beneficial. In the more thickly inhabited regions, however, where such food is scarce, they often do great damage by carrying off lambs, young pigs, kids, and poultry. As many as four hundred lambs are reported to have been taken from contiguous ranges in one season. It thus will be seen that in one instance the bird should be protected, and in the other kept in check.

The *bald eagle*, the emblem of our country, is found in suitable localities throughout the United States, though it is more common near large bodies of water than elsewhere. Its favorite food is fish, and when they can be obtained either by capture or in the shape of offal it will touch little else. A considerable proportion of the fish secured is taken from the osprey or fishhawk; still the eagle is fully capable of fishing for itself when necessity demands. Where fish are scarce or for any reason hard to procure, it will feed on waterfowl from the size

of large swans down to the smaller ducks and coots. Like the golden eagle, it preys on many of the destructive rodents in the West and is there considered a beneficial bird. Unfortunately, it is fond of lambs, pigs, and poultry, and probably does as much damage as the golden eagle in the more thickly inhabited regions. A great deal of sensational matter has appeared from time to time in the various newspapers about eagles attacking and carrying off children. Few of these stories

FIG. 23—Great Horned Owl (*Bubo virginianus*).

have any foundation in truth, though in olden times, when eagles had less fear of man, they may have picked up an unguarded infant.

The *pigeon hawk*, *Richardson's hawk*, and *Aplomado falcon* are all true falcons. Though they feed on the flesh of birds, they destroy enough insects and noxious mammals to partially offset the injury they do. The *prairie falcon* inhabits the dry Western plains and neighboring mountains, in the cliffs of which it builds its nest. Throughout a large portion of the country inhabited by this species, poultry is scarce, as most of the ranchers do not yet attempt to raise it. Although this

falcon feeds extensively upon waterfowl, quail, prairie chickens, and other game, it also attacks various kinds of injurious mammals, notably the smaller ground squirrels, such as the striped, Franklin's, Richardson's, Harris's, and the allied species, which abound in many sections of the country included in its range. In this respect it is of considerable service to the agriculturist, and probably offsets the injury done by destroying game; but, unfortunately, the data at hand are insufficient to show just how extensively it preys on these animals; hence the benefit done can not be correctly estimated.

One or other of the races of the large and handsome *great horned owl* is found throughout the United States where suitable timber exists for its habitation. It is a voracious bird, and its capacity for good or evil is very great. If we could pass over the more thickly settled districts where poultry is extensively raised and see the bird only as it appears in the great West, we would give it a secure place among the beneficial species, for it is an important ally of the ranchman in fighting the hordes of ground squirrels, gophers, prairie dogs, rabbits, and other rodents which infest his fields and ranges. Where mammals are plenty it does not seem to attack poultry or game birds to any considerable extent, but in regions where rabbits and squirrels are scarce it frequently makes inroads among fowls, especially where they are allowed to roost in trees. Undoubtedly rabbits are its favorite food, though in some places the common rat is killed in great numbers; we have one record of the remains of over one hundred rats that were found under one nest. The following is a list of the mammals we have found in the stomachs examined: Three species of rabbits, cotton rat, two species of pouched gophers, two species of wood rats, chipmunk, two species of grasshopper mice, white footed mouse, plateau ground squirrel, Harris's ground squirrel, muskrat, fox squirrel, five species of meadow mice, one short-tailed shrew, the house mouse, common rat, black bat, red-backed mouse, flying squirrel, shrew, and kangaroo rat. Besides mammals and birds, insects (such as grasshoppers and beetles), scorpions, crawfish, and fish are also taken. The great horned owl (fig. 23) does a vast amount of good, and if the farmers could be induced to shut up their chickens at night instead of allowing them to seek shelter in trees and other exposed places, the principal damage done by the bird would be prevented and the beneficial effects increased accordingly.

HARMFUL HAWKS AND OWLS.

We come now to the fourth class, the species of which are harmful, feeding, to a marked degree, on poultry and wild birds. In olden times, when falconry was a fashionable pastime, there were two types of hawks, each of which had its devotees. One, the true falcon, represented by the large gyrfalcon and the peregrine falcon, captured their quarry by superior power of flight in open country; while the other, the accipi-

trine hawks, represented by the goshawk, although strong fliers, succeeded in capture less by long flights than by short rapid dashes or by skillfully turning upon its unsuspecting prey. In the United States the injurious hawks belong to these two classes and are represented by closely allied species. The gyrfalcon and duck hawk are true falcons; while the goshawk, sharp-shinned, and Cooper's hawk are accipitrines. The gyrfalcons will not be considered, as they are northern species which very rarely enter the United States. The duck hawk also is so

FIG. 24.—Cooper's Hawk. (*Accipiter cooperi*).

uncommon, except about large bodies of water, that it plays an unimportant part in depredations upon poultry and upland game birds. During the migration of waterfowl along the seacoast, estuaries, large rivers, and lakes, the duck hawk has an abundant supply of food, feeding upon ducks, coots, waders, and even at times on gulls and terns. It is only during the breeding season that this falcon is ever troublesome to the farmer. An isolated pair may nest among the cliffs or in the giant trees of river bottoms near enough the agricultural districts to make daily inroads upon the farmyard. These cases are uncom-

mon, however, and usually by patient watching the robber can be captured before much harm is done.

One may find in the group of hawks embracing the goshawk, Cooper's hawk, and sharp-shinned hawk the probable cause for the unjust hatred and suspicion with which our birds of prey, as a whole, are held. All three species feed very largely upon the flesh of birds, of which game and poultry form a considerable part. As above mentioned, they capture their prey not so much by swift, long-continued flight in the open as by quick turns and rapid dashes from cover, the victim being grasped before the hawk's presence is really suspected. Fortunately, the *goshawk*, the largest of the three, is a northern species, and consequently is rare in most parts of the United States, except in fall and winter. It is a large, powerful bird, easily killing and carrying off a full-grown fowl, ruffed grouse, or hare. Many are the accounts told of its audacity in attacking poultry, taking it almost from under the very feet of the owner, and even entering inhabited houses in pursuit of its intended victim. It also has been known even to attack a person. A case of this kind happened to Dr. C. Hart Merriam, in northern New York. While in pursuit of a warbler with a small 22-caliber rifle, loaded with a light charge of dust shot, he heard a hen cry out in distress from behind a pile of stones. Guided by the sound, he soon reached the spot, and found a goshawk perched upon an old hen, not more than 10 feet distant. Aiming at its breast, he fired, but with no other effect than to arouse its wrath, for it immediately darted at his head with great fury. He struck at the hawk while on the wing and loosened a tail feather, but failed to knock it down. Meanwhile, the hen was making off, so, leaving the doctor, the hawk gave chase. She ran into some bushes which were so thick that the hawk could not fly between them, when, closing its wings and dropping to the ground, it followed in a succession of long, rapid hops, and quickly overtook her and pounced upon her back. She ran, carrying the hawk for nearly 100 feet. The doctor soon caught up and struck at the hawk with his empty gun, which it dodged by dropping on its back, after which it escaped to a neighboring tree and flew off. From the persistency with which this species hunts the ruffed grouse in many of the Northern States, it has received the name "partridge hawk." Mammals from the size of a full-grown hare down to the smaller mice are also captured, and it is stated that in the far north it feeds largely on lemmings.

Cooper's hawk is preeminently a "chicken hawk," and is by far the most destructive species we have to contend with, not because it is individually worse than the goshawk, but because it is so much more numerous that the aggregate damage done far exceeds that of all other birds of prey. Although not so large as the goshawk, it is strong enough to carry away a good-sized chicken, grouse, or cottontail rabbit. It is especially fond of domesticated doves, and when it finds a cote easy to approach without being observed, or near its retreat or

nesting ground, the inmates usually decrease at the rate of one or two a day until the owner takes a hand in the game. Some of these hawks have learned that safe and easy foraging is to be found in many of the large cities, where the use of firearms is prohibited. This is particularly the case in winter, when they congregate among the evergreens of the parks or shrubbery in the suburbs and sally forth upon the unsuspecting doves and English sparrows. If they confined their attentions to the pesky little sparrow they would be public benefactors, as the problem of keeping that imported nuisance in check might be easily settled. Among the mammals which are eaten by Cooper's hawk, the arboreal and ground squirrels appear to be most frequently taken. Remains of chipmunks, red squirrels, and gray squirrels have been found in the stomachs.

The *sharp-shinned hawk*, an almost perfect miniature of Cooper's hawk, is fully as destructive to bird life as its larger congener. Although rarely attacking full-grown poultry, it is very partial to the young, and often almost exterminates early broods which are allowed to run at large. No birds, from the size of doves, robins, and flickers to the smallest warblers and titmice, are safe from its attacks. In our previous examinations of the stomachs of this hawk, the remains of nearly fifty species of birds were recognized, and the list is of so much interest in showing the variety of kinds that it is here repeated: Arizona quail, mourning dove, downy woodpecker, red-shafted flicker, yellow-shafted flicker, chimney swift, cowbird, orchard oriole, grackle, housefinch, goldfinch, savanna sparrow, western savanna sparrow, white-throated sparrow, field sparrow, chipping sparrow, tree sparrow, junco, song sparrow, fox sparrow, English sparrow, Abert's towhee, red-eyed vireo, black and yellow warbler, black-throated green warbler, yellow-rumped warbler, bay-breasted warbler, blackpoll warbler, pine-creeping warbler, ovenbird, Maryland yellowthroat, blackcap, western blackcap, Canada warbler, mockingbird, catbird, crissal thrasher, cactus wren, Carolina wren, red-bellied nuthatch, chickadee, ruby-crowned kinglet, gray-cheeked thrush, hermit thrush, robin, and bluebird. To show how universally this species feeds on small birds, it is only necessary to say that of 107 stomachs containing food, 103, or $96\frac{1}{4}$ per cent, contained the remains of birds. Mammals and insects seem to be taken rarely, and when they are, mice and grasshoppers are the ones most frequently chosen. This species, like the Cooper's hawk, has increased during recent winters about the large cities of the East, doubtless because it finds the sparrows numerous and easy to procure.

THE CROW BLACKBIRDS AND THEIR FOOD.

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GEOGRAPHIC RANGE.

Throughout the Eastern States and Mississippi Valley the grackle or crow blackbird is one of the most familiar and conspicuous birds. It appears in spring and early summer about farmhouses and villages, where it finds its favorite nesting places. Five different kinds occur within our borders, but the present paper is concerned only with the common purple grackle (*Quiscalus quiscula*) and its two subspecies,

Fig. 25.—The Crow Blackbird.

the bronzed grackle (*Quiscalus q. æneus*) and the Florida grackle (*Quiscalus q. aglæus*). The purple grackle is abundant in the region east of the Alleghanies as far north as New York, and is found sparingly in New England. The Florida grackle is distributed over the region extending from the coast of South Carolina southward into the peninsula of Florida and westward to Louisiana. The bronzed grackle occupies the Mississippi Valley and Great Plains as far west as the Rocky

Mountains, ranges northward to Great Slave Lake and southern Newfoundland, and east to the coast of southern New England (fig. 25).

In Canada and the northern United States the crow blackbird is only a summer resident, but in the Southern States it is present throughout the year, and in winter its numbers are increased by millions of migrants from the north which find here a congenial winter home. It does not occur south of the Gulf States, and stragglers have been found during the cold months as far north as Illinois, and even Minnesota.

At the first approach of spring, the crow blackbirds begin to move northward, closely following the retreat of winter. During the summer months they cover the whole of the United States east of the Rocky Mountains, except New England, though they are most plentifully distributed over the great grain-raising States of the Northwest. In New England crow blackbirds are of local occurrence. They are tolerably abundant in Connecticut, but in the more northern States breed in certain favored localities only, and are entirely absent from large areas.

In the northern United States the southward movement begins about the end of September, although the habit of collecting in flocks immediately after the breeding season confirms the belief that the birds disappear from many localities during the month of August. It thus appears that their stay in the northern part of the country is limited to the six warmest months of the year; hence whatever they do that is either beneficial or injurious must be accomplished during that time. In the South, on the contrary, they are found throughout the year, and in largely increased numbers during the winter. Fortunately, however, this is not the season of growing crops, so that the damage done is principally confined to the pilfering of grain left standing in the shock. It is probable, however, that at this season they feed largely on weed seeds, mast, and waste grain scattered in the field.

The crow blackbird is a gregarious species, usually breeding in colonies and migrating in flocks. In fall the young and old collect in large assemblages, which in the Mississippi Valley often grow to enormous size. The redwing (*Agelaius phœniceus*), Brewer's blackbird (*Scolecophagus cyanocephalus*), and rusty blackbird (*S. carolinus*) often associate with them.

Moving southward, immense flocks cross the Red River Valley between Texas and Indian Territory. In September, 1886, Mr. George H. Ragsdale reported that at Gainesville, on the Texas side of the river, "the flocks were of such size that the roar of their wings could be heard for a quarter of a mile;" and, according to a statement published in a local paper, one person had on hand 8,000 blackbirds which had been netted for the use of gun clubs. Mr. Ragsdale stated that at the same time the grass worm was destroying the crab grass and purslane, and attributed the unusually large flocks of blackbirds to the fact that the early fall migrants, finding so many worms, had halted until the

bulk of the birds drifted southward. About the first of October the worms and birds disappeared simultaneously.

Crow blackbirds are well known to the farmer as foragers about the barnyard and pigpen. When they arrive in spring, after their long journey from the south, they are apt to depend on the corncrib for some of their first meals, but when the plow begins its work they are on the alert, and follow it up and down the furrows, seizing every grub or other insect that may be turned up. Their industry in this respect is very noticeable, and if not disturbed or frightened in any way, they often become so tame as scarcely to get out of the way of the team in their eager search for food. Very soon a nest is built, and in a short time four or more gaping mouths demand to be filled, and the parent birds must then work harder and go farther afield to provide for the increased number of stomachs. When the cherries and other early fruits ripen the birds take a share for themselves, thinking no doubt that they are fairly entitled to them for the good work they did earlier in the season. When the corn "comes into the milk" they also take a portion.

OBSERVATIONS REGARDING THE DIET OF THE CROW BLACKBIRD.

In the selection of food the crow blackbird is almost omnivorous. Its partiality for corn, wheat, rice, oats, and other grain is well known, and is the cause of nearly all the complaints about its depredations. This diet is supplemented by various fruits, berries, nuts, seeds, and insects, the latter in large proportion. But the character of the food varies materially with the season. During the fall and winter blackbirds subsist largely on seeds and grain; as spring approaches they become more insectivorous; in summer they take small fruits, and in September they attack the ripening corn, but at all seasons they undoubtedly select the food that is most easily obtained.

To this varied diet are due the conflicting statements respecting the useful or noxious habits of the species. When feeding on grain the birds are usually in large flocks, their depredations are plainly visible, and they are almost universally condemned. When breeding they are less gregarious, and the good work they do in the fields is scarcely noticed, although at this season the grubs and other insects devoured compensate in large measure for the grain taken at other times. As Mr. N. W. Wright, of Farmland, Ind., aptly says: "It is hard to tell on which side to place the crow blackbirds, for we can see the damage done, but not the benefits."

During the spring they destroy many noxious insects. Prof. D. E. Lantz states that at Manhattan, Kans., from the time of their arrival until August they feed almost entirely upon cutworms, and Prof. Herbert Osborne, of Ames, Iowa, reports that during the spring of 1883 he saw them destroy great numbers of the May beetle (*Lachnosterna fusca*), and found them feeding on it for several weeks. Grasshoppers,

crickets, locusts, and other insects are also largely eaten. Mr. J. Percy Moore, of Philadelphia, Pa., wrote in 1885:

> During the recent visit of the 17-year cicada this species (the purple grackle) devoured immense numbers of pupæ and imagos. It also ate large numbers of the grubs of the June bug, which it generally obtained by searching in the furrows in newly plowed fields, and all stages of the Carolina and other grasshoppers, the common white butterfly (I saw one catch several of this species on the wing May 26, 1885), and other species not identified.

Mr. W. B. Hall, of Wakeham, Ohio, gives an interesting account of some young grackles which were kept in captivity. He says:

> I have captured the young and confined them in a cage in such manner that the old bird could not reach the mouth of the young. The food brought consisted largely of larvæ of *Coleopterous* and *Lepidopterous* insects, with an occasional beetle. If freshly plowed fields were in the vicinity the food consisted largely of the white grub and cutworm, a few tent caterpillars, one worm that I took to be a small *Attacus*, and beetles of the genera *Galerita*, *Cetonia*, *Lachnosterna*, and their kindred.

Recently an estimate of the amount of food required to support a large flock of blackbirds has been made by Mr. H. H. Johnstin, of London, Ohio. During the present autumn (1894) he counted 1,100 blackbirds one morning as they left their roosting places for the feeding grounds, and estimated that the birds which flew by would number 50,000. Allowing 2 ounces as the quantity of food collected by each bird during the day, he arrived at the conclusion that 6,250 pounds, or more than 3 tons, of food was consumed by this army of blackbirds in a single day. Even if the number of birds in this case is not overestimated, the amount of food per bird is undoubtedly too great. The species of blackbirds to which these notes refer are not stated, but it is safe to assume that the flocks were made up of redwings (*Agelaius*) and crow blackbirds (*Quiscalus*). A full stomach of the crow blackbird, selected at random from specimens in the collection of the United States Department of Agriculture, was found to weigh 0.158 ounce, or 2.25 drams, while the contents of another stomach weighed only 0.116 ounce, or 1.85 drams. The average of two full stomachs of red-wing blackbirds was 0.049 ounce, or 0.78 dram, and the stomach contents of a third weighed only 0.021 ounce, or 0.33 dram. While of course these figures do not give the quantity of food a bird consumes in twenty-four hours, they show that the full stomach of a blackbird weighs comparatively little. In order to consume 1 ounce of food per day a crow blackbird must eat six or eight full meals, depending on the kind of food, and the redwing twice as many. Even with this estimate, the amount consumed by the flock of 50,000 birds would still be more than a ton and a half per day. Although these figures are probably still too large, they serve to give some idea of the quantity of grain a large flock could destroy.

Briefly stated, the accusations against the crow blackbird relate mainly to the destruction of grain, especially corn, soon after planting

in the spring, and again in the autumn, when the corn is in the milk and nearly ripe. In the Southern States the grackles destroy rice also. In some sections they are said to feed upon young grain in such quantities as seriously to injure the value of the crop, and for this reason they are poisoned in large numbers. A more effectual method is to prevent the birds from taking the seed by tarring the corn before it is planted; this is better, simpler, and cheaper than the wholesale destruction of the birds.

Mr. S. T. Kimball, of Ellington, Conn., gives his experience with the crow blackbird, as follows:

> As a rule, farmers here tar their corn, but last June I sowed some without tarring, and the result was that by the time it was out of the ground the blackbirds had attacked it. They worked all day, carrying their bills full—load after load—to a cemetery where there is quite a colony. They kept this up till the corn was entirely absorbed by the stalk, although I shot some five or six of them.

Mr. George K. Cherrie states that in Monona County, Iowa, during the spring of 1884, both the crow blackbird and the yellow-headed blackbird did considerable damage by pulling the corn just as it came through the ground, and were poisoned in great numbers by corn which had been soaked in water containing arsenic. Similar depredations are sometimes committed in the rice fields of the South.

According to Mr. W. C. Percy, jr., of Bayou Goula, La., the crow blackbirds destroy rice and corn to a great extent, and would do so totally were not men stationed with guns. They eat it in planting time only.

Mr. S. Powers, of Lawtey, Fla., writes: In this climate corn is left on the stalk as long as possible, to escape the weevils, and the blackbirds eat the ends of many ears, sometimes one-third of their length.

In the autumn, when the corn begins to ripen, the fields are again visited by blackbirds in larger flocks than in the spring, and, to the dismay of the farmer, the birds renew their work of destruction. Mr. Daniel S. Wardsworth reports that in a field of 2 acres near Hartford, Conn., the grackle has been known to ruin from one-third to one-half of a crop of corn in the milk or when ripe. A similar complaint was made by Mr. George H. Selover, of Lake City, Minn.

Another accusation often made against the crow blackbird is that it destroys the eggs and young of other birds. It will be well to examine the testimony on this point with some care, because the charge is often repeated and because the examination of a large series of stomachs does not substantiate it except in an exceedingly small percentage of cases. A cursory examination of the statements of writers shows that very few are based on original observation; the majority are either repeated from the observations of others or are taken from published accounts of the bird's habits. The following extracts from letters are from reliable persons who have actually seen the blackbirds destroy the eggs or young of other birds.

Mr. H. Nehrling, writing from Freistatt, Mo., on December 5, 1885, says:

Sometimes they breed in orchards, where they become great enemies of our small birds. I have observed them destroying eggs of bluebird, cat-bird, and flycatcher (*Empidonax pusillus*), and have seen them carry off the young of the field sparrow and other small birds.

Mr. George H. Selover, of Lake City, Minn., writes:

Several times each season I have seen the bronzed grackle steal the eggs of the chipping sparrow and other small birds, but have not observed them take the young. Have never known them to drive off other birds.

Mr. P. L. Ong, of Hennepin, Ill., says:

The crow blackbird has been seen to throw young robins out of the nest and tear the nest in pieces. It has not driven any birds from this neighborhood, and does not seem to make a business of destroying the eggs and young.

Mr. W. F. Hendrickson, of Long Island City, N. Y., states: I have known purple grackles to eat robins' and thrushes' eggs, and in at least one instance the young of the robin.

Mr. Morris M. Green, of Syracuse, N. Y., says: I have seen the crow blackbird attack robins' nests and break the eggs.

These observations have been selected from notes contributed by several hundred observers, and are quoted in full to show the extent to which the grackle is said to injure other species. From such statements it can not be doubted that these birds do occasionally destroy the eggs of the robin, bluebird, chipping sparrow, small flycatchers and other species, and more rarely the young of the robin. Let us see what the stomachs themselves show. Of the 2,258 stomachs examined, only 37 contained any trace of birds' eggs, and 1 contained the bones of a young bird. These were distributed as follows: In April, 9; May, 9; June, 7; July, 7; and August, 5. The greatest quantity of eggshell was found in May, aggregating forty-six one-hundredths of 1 per cent of the food for that month. This certainly does not show that the blackbirds are much given to robbing their neighbors. Still further, the eggshells found in a number of stomachs were identified as those of domestic fowls, probably obtained from compost heaps, where they had been thrown. Hence it seems fair to infer that the grackle indulges its nest-robbing proclivities only occasionally, and that the prevalence of the habit has been considerably exaggerated.

EXAMINATIONS OF STOMACH CONTENTS.

It may be well now to take up the results of actual examinations of the stomach contents in other cases, and see how far the observations made in the field are borne out by the studies made in the laboratory.

Nearly 2,300 crow blackbird stomachs have been examined, of which 2,258 contained food; the remainder were empty. These stomachs were obtained from twenty-six States, the District of Columbia, and New

Brunswick. Kansas and Dakota are the most westerly States in which any were collected, and Tennessee and Virginia the most southerly, except Florida. They were taken during every month in the year except January, but as the great body of the species leaves the Northern States in October and does not return until March, but few stomachs could be procured in November, December, and February. Great pains were taken to secure a large number during May and June, the breeding months, with the result that a little more than half of the whole collection was obtained in these months. Observation has shown that the food of young birds often differs materially from that of the adults, and in order to test this point in the present species 486 nestlings were collected in May and June, and have contributed their quota to the final result.

The first step in the determination of the food is to separate the stomach contents into its three most important categories, viz, animal, vegetable, and mineral matter, and to estimate the percentage of each. In the present case the result for the food of the whole year, taking into account the entire number of 2,258 stomachs, young and adult, was: Animal food, 48 per cent; vegetable, 48 per cent; mineral, 4 per cent. The animal food was found to be composed of the following elements: Insects, spiders, myriapods, crawfish, earthworms, sowbugs, hair snakes, snails, fishes, tree toads, salamanders (newts), lizards, snakes, birds' eggs, and mice.

The insect food constitutes 46 per cent of the entire food for the year, and is the most interesting part of the bird's diet from the economic point of view. For convenience, spiders and myriapods (thousand-legs) are here classed with the insects. In examining the insect food month by month, we find the smallest quantity in February, when it is less than 6 per cent of the whole food; but as only three stomachs were taken, the result can not be considered as very reliable. In March the insect food rises to one-fifth, and steadily increases till May, when it reaches its maximum of five-eighths of the whole. It then decreases until in October it is only one-eighth. It appears to rise in November and December, but the number of stomachs taken in those months is too small to warrant any general conclusions. The great number of insects eaten in May is due in part to the fact that the young which are batched in that month are fed largely on that kind of food.

VARIOUS ARTICLES OF BIRD DIET.

An analysis of the insect component of the food presents many points of interest. Let us first consider the beetles, an order of insects known to everybody, and easily distinguished in most cases by the hard outer wing covers. Among the most important families are the Scarabæids, every member of which is or may be injurious to agriculture, either in its early stages as a grub, or after coming to the adult form, or, as is often the case, in both. The common June bug or May beetle and

the rosebug are familiar examples of this family. The well-known grubworms, so often turned up by the plow in spring, are the young or larval forms of these beetles. An examination of the stomachs of blackbirds shows that these insects were eaten, either as beetles or grubs, in every month from March to October, inclusive. In May they constituted more than one-sixth and in June one-ninth of the entire food. The habit these birds have of following the plow to gather grubs is a matter of common observation which has been fully confirmed by the stomach examinations. Many stomachs were found to be literally crammed with grubs, and in many more, where other food predominated, the presence of their hard jaws showed that grubs had formed a goodly portion of a previous meal.

The curculios, snout beetles, or weevils constitute another family of beetles unfortunately well known to fruit growers, the plum curculio being a too familiar example. Like the Scarabæids, these beetles were eaten in every month from March to October, and while taken in great numbers, the individuals are so small that the percentage of bulk does not rise as high as in the case of the Scarabæids. The maximum is reached in June, when the weevils constitute 6 per cent of the total food, with a gradual decrease in the succeeding months. Insects of such small size could hardly be obtained except by diligent search, and their presence in so many stomachs (772), and also the large numbers in single stomachs (sometimes reaching 30 or even 40), warrants the conclusion that they are sought as choice articles of food.

Many other beetles were found in the contents of the stomachs, but with one exception, in quantities too small to be of much economic interest. The Colorado potato beetle was not present, but several species belonging to the same family were identified. The one exception referred to above is that of the Carabids or predaceous beetles. These insects, from their habit of preying upon other insects, have always been reckoned as beneficial to agriculture, and this is no doubt a true verdict; hence the bird which eats them is, to that extent, doing the farmer an injury. Now, we find that the blackbirds have eaten Carabids in every month from March to November, inclusive, and although there is considerable variation in the quantity during the several months, the variation is less than in any other insect. They begin by eating more than 4 per cent in March, attain a maximum of 13 per cent in July, and end with a little over 1 per cent in November. From these figures it would seem that the predaceous beetles are highly prized by the blackbirds as an article of food, and, although this may be true, there are other facts that have a bearing on the case. Most of these beetles are of fair size and easily seen, and many of them are quite large; moreover, they live upon the ground and are much oftener seen running than flying. They are the first beetles observed in spring, and are usually abundant at all times when insects are to be found. When we consider that the blackbirds seek a great portion of their food upon the ground,

it is at once apparent that these beetles must naturally fall in their way oftener than any others.

The above remarks are not intended to vindicate the birds in the habit of eating useful insects, but merely to suggest that such insects may be eaten more from necessity than from choice. It does not necessarily follow that birds are doing harm by eating insects that are classed as useful on account of their food habits. This point has been enlarged upon in another place, and has been more fully elucidated by other writers, notably by Prof. S. A. Forbes (Bull. Ill. State Lab. Nat. Hist., Vol. I, No. 3).

Next in importance to beetles as an article of blackbird diet are the grasshoppers. For convenience, grasshoppers, locusts (green grasshoppers), and crickets are considered in the same category. Of the three, the true grasshoppers are by far the most numerous in the stomachs, and were eaten in all months in which stomachs were taken except December. In February they constitute 2 per cent of the total food, and the fact that they were found at all in this month indicates that the birds are keen hunters, for it would puzzle an entomologist to find grasshoppers in February in most of the Northern States. It is possible that some of those eaten in February and the succeeding month were dead insects left over from the previous year. The proportion of grasshoppers in the stomachs increases with each month up to August, when it attains a maximum of nearly one-fifth of all the food. It is worthy of note that crickets, considered apart from grasshoppers, reach their maximum in June, when they form something over 5 per cent of the monthly food.

After August the grasshopper diet falls off, but does not entirely disappear, for even in November it still constitutes 6 per cent of the total for the month. The frequency with which these insects appear in the stomachs, the great numbers found in single stomachs (often more than 30), and the fact that they are fed largely to the young, all point to the conclusion that they are preferred as an article of food and eagerly sought at all times. The good that is done by their destruction can hardly be overestimated, particularly as many of the grasshoppers found in the stomachs were females filled with eggs.

Another interesting element of this bird's food is the caterpillars or larvæ of butterflies and moths. These were found in every month in which stomachs were taken except November, while December, curiously enough, showed the highest percentage; but as this result was obtained from only two stomachs the result may be discarded as unreliable. The quantity of caterpillars and larvæ consumed was about 1½ per cent for each month except May, June, and August. In May a maximum of something more than 9 per cent was reached, followed by a little over 4 per cent in June, and falling to a minimum of less than 1 per cent in August.

Most persons who have picked and eaten berries directly from the bushes have had the disagreeable experience of getting into their mouths a small bug which is a little too highly flavored to suit the taste of the human race, but which is eaten by our feathered friends in every month from February to October, inclusive. They are not, however, consumed in large quantities, probably for the reason that great numbers can not be found; still, traces of them appear in many stomachs, indicating that the birds eat as many as they find.

In addition to the insects specified, representatives of several other orders were found in the blackbirds' stomachs, but not in such large or regular quantities as to render them an important element of food. Spiders and myriapods (thousand-legs) were also noted in sufficient numbers to demand recognition. They were eaten to some extent during every month, but not, as a rule, in large quantities. The spiders attain a maximum of 6 per cent in May, and not only the spiders themselves but their cocoons full of eggs appear to have been taken whenever found. The myriapods were eaten somewhat less frequently, but appear in nearly every month.

GRAINS AND FRUITS AS BLACKBIRD FOOD.

The vegetable component of the stomach contents is as variable and diversified as the animal food, showing plainly that when one article of diet is wanting, the bird can make up the deficiency by eating something else which is more easily obtained. The following list includes all the vegetable substances identified in the 2,258 stomachs, but there were, of course, some that could not be positively determined. The pulp of fruit, when unaccompanied by seeds and already half digested, is difficult to distinguish with precision, and the same is true of the hulls or skins left after kernels of grain have been digested and have passed away, but the total of such unrecognized matter is not great.

List of vegetable substances found in stomachs.

Grain	Corn. Oats. Wheat. Rye. Buckwheat.
Fruit	Blackberries and raspberries (*Rubus*). Strawberries (*Fragaria*). Cherries (cultivated). Mulberries (*Morus*). Currants (*Ribes*). Grapes. Apples. Blueberries and cranberries (*Vaccinium* sp.). Huckleberries (*Gaylussacia* sp.). Dogwood berries (*Cornus* sp.). Elderberries (*Sambucus* sp.). June or service berries (*Amelanchier canadensis*). Hackberries (*Celtis occidentalis*).

List of vegetable substances found in stomachs—Continued.

Seeds and nuts of shrubs or trees	Poison ivy (*Rhus radicans*).
	Harmless sumac (*Rhus glabra et al.*).
	Wax or bayberries (*Myrica cerifera*).
	Hornbeam (*Ostrya virginiana*).
	Chestnuts and chinquapins (*Castanea dentata* and *pumila*).
	Beechnuts (*Fagus atropunicea*).
	Acorns (*Quercus*).
Weeds	Ragweed (*Ambrosia*).
	Barn grass (*Setaria*).
	Gromwell (*Lithospermum*).
	Smartweed (*Polygonum*).
	Pokeweed (*Phytolacca*).
	Sorrel (*Rumex*).
Miscellaneous	Small bulbs or tubers.
	Galls containing larvæ.
	Pieces of plant stems.
	Bits of grass and leaves.
	Thorn of locust (*Robinia*).
	Pieces of rotten wood.

Of all these various articles of diet the chief interest centers about the grain and fruit, for it is through these that the blackbirds inflict the greatest damage upon the farmer; in fact, the worst that has been said of them is that they eat large quantities of grain. Of the five grains named in the list, corn is the favorite, having been found in 1,218 stomachs, or more than 53 per cent of the whole number. It is eaten at all seasons of the year, and in every month except July and August amounts to more than one-half of the total vegetable food. The corn obtained in winter and until planting in the spring can be but little loss to the farmer, as it must be mostly waste corn. This view was fully confirmed by the contents of a series of stomachs taken in early spring, which contents consisted to a great extent of corn that had evidently been wet and frozen, and had lain out all winter. After February there is a steady decrease in the quantity of corn eaten until July, when it reaches a minimum of 7 per cent. The month of May does not show any increase over the preceding months, although it is the time for planting; nor is there an increase in June, which in the north is the month of sprouting corn. In fact, very little evidence was found to indicate that blackbirds pull up sprouting grain. In this respect they differ conspicuously from the crow. In August the corn amounts to one-eighth of the whole food, and it, together with a part of that taken in September, was green corn "in the milk." The maximum amount, nearly 53 per cent, is eaten in September, and this is undoubtedly wholly taken from the fields of standing corn, representing so much good grain contributed by the farmer. The same is true for October, when the quantity eaten is nearly as great as in September (47 per cent), and in the Middle and Western States, where grain often stands in the fields until December; this must also be the case up to the end of November.

Next to corn, but far behind it in importance, come oats, which were eaten in very irregular quantities in every month except November and December. They appear in the greatest amount in April, when they constitute a little more than one-eighth of the total food. They fall to less than 1 per cent in June, but rise to over 8 per cent in August. The oats eaten in April are probably picked up from newly sown fields, and those taken in August and September are probably gleaned from fields after harvest, while those found in the other months are accidental and of no importance.

Wheat was eaten in every month from April to October, inclusive, but makes very little showing except in July and August. In these two months it formed, respectively, about 19 and 17 per cent of the whole food, these being the only months in which it reached a higher percentage than corn or any other item of vegetable food. As July and August are the months of the wheat harvest, it is easy to account for the large amount eaten by the blackbirds at that time; but whether the grain so eaten is taken from the standing crop, or is merely the scattered kernels gleaned after the harvest, must be left for the observing farmer to find out. Probably the birds take whichever is more accessible.

Rye was found in only 1 stomach, and buckwheat in 9. The former was from a bird taken in May in Pennsylvania, and is evidently not a favorite food. Three birds taken in New Jersey in February were found to have eaten a small quantity of buckwheat. A single bird from New York, killed in July, and one from Iowa, killed in September, had also eaten this grain, as had another lot of four birds from New Jersey taken in November at the same time and place. The buckwheat eaten in February and November must have been waste grain, and the fact that birds from the same localities, taken at the time when this grain was harvested, had not eaten it, indicates that it is not a desirable food, and is only eaten under stress of hunger.

It is unfortunate that the collection contains so few stomachs from the Southern States, where crow blackbirds remain through the winter months. In reports received from this region it is stated that the crow blackbird preys upon the rice fields, in company with other blackbirds and the bobolink, the latter being the well-known ricebird of the South.

Although fruit of some kind was eaten in every month from March to December, inclusive, it does not become of importance until June, July, and August, when it reaches 6, 14, and 11 per cent, respectively. This aggregate is made up from a number of elements, as will be seen by referring to the list on page 242. Of these the only ones likely to possess any economic interest are blackberries, raspberries, cherries, currants, grapes, and apples. Apple pulp was found in 3 stomachs, grapes in 3, currants in 1, cherries in 37 in June and 14 in July, and strawberries in 7. The blackberries and raspberries were the favorites, and made up the great bulk of the fruit eaten. They were eaten from

May to September, inclusive, but only a few in each month, except in July and August, when they were found in 96 and 68 stomachs, respectively. When we consider that these last-mentioned fruits are much more abundant in the wild than in the cultivated state, and bear in mind the small number of birds that eat other fruits, it certainly must appear that the damage the blackbirds do by eating fruit is of no great moment. None of the wild fruits mentioned in the table were found in large quantities or in many stomachs.

Mast, under which term are included chestnuts, chinquapins, acorns, and beechnuts, forms quite an important element of food in the fall and early spring months. In March it constitutes nearly one-tenth of the food, and in September it reaches nearly one-seventh, being, after corn, the most prominent vegetable constituent in that month. In October it amounts to one-eighth of the whole food.

SEEDS AS BIRD FOOD.

The seeds of the various plants included under the head of "weeds" in the list on page 243 form another interesting element of vegetable food, and are of considerable importance in the colder months. Beginning in February, they form one-eighth of the food, and gradually diminish in quantity until June, when they almost disappear. They then increase until October, when they attain a maximum of over one-eighth, forming, next to corn, the largest percentage of vegetable food in that month. As all the plants included in this category are nuisances, it is perhaps needless to say that by eating weeds the birds are doing a good work.

The mineral component of the food does not possess much if any economic interest, but it is curious to note how many different things a blackbird can pick up. Sand, gravel, pieces of brick, bits of mortar, plaster of paris, charcoal, hard coal, and cinders were the most common of the various hard substances which helped to line the mill in which their corn was ground.

FOOD OF THE YOUNG.

As previously stated, 486 nestlings are included in the 2,258 birds whose food has been already discussed. A separate study was made of these in order to ascertain in what respect, if any, their food differed from that of the adults. It would have given more satisfactory results if it had been possible to separate the younger nestlings, say those under 1 week of age, from the older ones, for it was noticed that as the young approach maturity and get ready to fly their food becomes more like that of their parents. The young were collected from May 22 to June 30, inclusive, and represent every age, from the newly hatched to those about to leave the nest. The whole stomach contents, when separated into its three principal components, was found to be as

follows: Animal matter, 70 per cent; vegetable, 25 per cent, and mineral, 5 per cent. The much higher percentage of animal food in the young as compared with the adults (48 per cent) is at once noticeable, although it may be insisted that the food of the young should be compared with that of the adults in the corresponding season; that is, in the months of May and June. If this view be taken, the difference is not so great. The percentage of mineral matter also is a little greater than in the adults.

The animal food is practically the same as that of the parent birds, and likewise consists chiefly of insects. These amount to 66 per cent, 20 per cent more than in the adults. The animal food other than insects, amounting to less than 5 per cent, is not important enough to merit attention. The insect food is made up of about the same kinds as are eaten by the old birds, but in somewhat different proportions. Adult beetles, on account of their hard shells, are not fed to very young birds, but a few are given to the older ones. "Grubworms," the larvæ of Scarabæids, are fed freely after the first or second day. A little more than 14 per cent of the food of the nestlings consists of this family of beetles, and for the most part in the form of the larvæ or grubs. Predaceous beetles (Carabids) constitute about 7½ per cent of the food, weevils a little more than 3 per cent, and there were traces of five or six other families, none of which reached 1 per cent.

Grasshoppers and crickets, the former predominating, are a favorite food for the young, being softer and more easily digested than beetles. They constitute about one-fifth of the total food, that is, as much as the parent birds consume in August, and nearly three times as much as they eat in May and June, when they are feeding the young. This shows that they select the grasshoppers and other soft insects for their offspring, while they eat beetles and other hard things themselves.

Caterpillars constitute something over 6 per cent of the food of the young birds, which is not as much as might be expected when we consider how soft and apparently well adapted they are for this purpose.

Besides the insects already mentioned, small quantities of ants, flies, bugs, May flies, myriapods, and spiders were given to the young. These last merit a special notice from the fact that they form the earliest food of the bird. A number of tiny stomachs were examined, evidently taken from birds less than 24 hours old. In nearly every case they contained either a single spider or several very small ones—undoubtedly the bird's first meal. The very young stomachs are thin, almost membranous sacs, entirely unlike the stout, muscular gizzards of the adult birds, which explains why soft, easily crushed food is required for the newly hatched young. It is only after they have attained considerable growth and the stomach walls have become somewhat muscular that they are able to digest such food as hard beetles and corn.

The vegetable food of the young consists of corn and fruit, with mere traces of half a dozen other things. Corn amounts to over one-eighth of the total food, but is fed only to the older birds, whose stomachs have acquired the requisite muscular strength to digest it. Fruit constitutes about 6½ per cent of the food, almost exactly the same quantity as was consumed by the adults in the month of June, and consists of the same varieties.

A number of substances are found in the blackbirds' stomachs that can hardly be considered as food. These are usually reckoned under the head of "rubbish," and are probably for the most part taken accidentally. Such are bits of dead leaves, pieces of bark, rotten wood, bits of plant stems, and dead grass, all of which might be carelessly swallowed in picking up a kernel of corn or seizing an insect. The quantity of refuse eaten by the adults varies from 1 to 2 per cent of the whole food in each month, but, curiously enough, the stomachs of the young contain more, amounting to nearly 4½ per cent. It would seem that while the old birds are very judicious in selecting a suitable diet for their nestlings, they are less particular in rejecting the substances that accidentally adhere to the food.

SUMMARY.

From the foregoing results it appears that if the mineral element be rejected as not properly forming a part of the diet, the food of the crow blackbird for the whole year consists of animal and vegetable matter in nearly equal proportions. Of the animal component twenty-three twenty-fourths are insects, and of the insects five-sixths are noxious species. The charge that the blackbird is a habitual robber of other birds' nests seems to be disproved by the stomach examinations.

Of the vegetable food it has been found that corn constitutes half and other grain one-fourth. Oats are seldom eaten except in April and August, and wheat in July and August. Fruit is eaten in such moderate quantities that it has no economic importance, particularly in view of the fact that so little belongs to cultivated varieties.

The farmer whose grain is damaged, if not wholly ruined, by these birds may attempt to count his loss in dollars and cents, but the good services rendered by the same birds earlier in the season can not be estimated with sufficient precision for entry on the credit side of the ledger. Thoughtful students of nature have observed that there is a certain high-water mark of abundance for every race or species beyond which it can not rise without danger of encroaching upon and injuring other species, not even excepting man. This is true of every species in nature, whether it be one which, at its normal abundance, is beneficial to man or otherwise. To no group does this apply with more force than to the insects, many species of which frequently exceed their ordinary bounds and spread destruction among crops. The same argument applies to the birds. However useful they may be in a general way, there

is danger that they may become too numerous. While the destruction of a noxious insect is greatly to any bird's credit, still it is believed that the principal value of the useful bird lies not so much in this special work as in keeping the great tide of insect life down to a proper level. The examination of the food of the blackbirds has shown that they do a good share of this work, and are therefore most emphatically useful birds. This does not mean that they do no harm, or that they should be permitted to do all the harm they wish without restraint. It is not probable that the grain eaten by blackbirds under ordinary circumstances occasions much loss to the farmer, because so much of it consists of scattered or waste kernels. When, however, they descend upon a corn or wheat field in flocks of hundreds or thousands they inflict a real damage; and this simply shows that the species is too abundant and ought to be reduced, or that the birds have assembled from all the surrounding country and have become too crowded in one restricted locality. In either case the farmer should protect himself by any practicable means and should not submit quietly to being robbed merely from a sentimental idea of the bird's past or probable future usefulness. If the crop and the birds' lives can both be saved, well and good; but if not, let the extreme penalty be paid.

Upon the whole, crow blackbirds are so useful that no general war of extermination should be waged against them. While it must be admitted that at times they injure crops, such depredations can usually be prevented. On the other hand, by destroying insects they do incalculable good.

SOME SCALE INSECTS OF THE ORCHARD.

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INTRODUCTORY.

For many years prior to a recent date our Eastern orchards were comparatively free from serious damage by scale insects, or "bark lice," as they are indifferently termed. Barring the old and well-known oystershell bark louse of the apple, orchardists were not often compelled to fight any insects of this group, and even this species, abundant and widespread as it is, had come to be considered, as it still is, a rather unimportant factor in apple raising, seldom necessitating treatment in otherwise healthy and vigorous orchards.

Within the past few years, however, conditions as regards scale insects in general have changed. The San Jose, or pernicious, scale of the Pacific Coast has come east and threatens great damage; the new peach scale has made its way across to Florida from the West Indies, and is now destroying trees as far north as the District of Columbia; the peach Lecanium has apparently increased and spread, and has caused considerable alarm in several large nurseries; the so-called walnut scale has transferred its attentions to the pear and peach in the South and Southwest, and the greedy scale, although found, until recently, only on the Pacific Coast and in the far Southwest, levies a heavy annual tax on the fruit growers of those regions, and has the present season made its appearance in Mississippi and Texas.

A popular article upon these insects, describing them in such a way as to enable the fruit grower readily to identify any form which he may have upon his trees, and giving some account of the best remedies which may be used, will be timely, and such the present article aims to be. It is confined to the scale insects of deciduous fruit trees for the reason that the insect enemies of citrus fruits will receive full treatment at the hands of Mr. Henry G. Hubbard, an assistant in the Division of Entomology, who is preparing an elaborate revision of his report on the insects affecting the orange, the publication of which may be brought about before many months. There are several additional important scales which affect small fruits like the raspberry, blackberry, grape, and currant, but these are excluded from this consideration simply from want of space. Several of the scales treated, however, although more commonly found upon orchard trees, attack also these small fruits.

LIFE HISTORY AND HABITS OF SCALE INSECTS IN GENERAL.

In respect to life history, the family Coccidæ, which includes all of the so-called scale insects, is very abnormal. The eggs are laid by the adult female either immediately beneath her own body or at its posterior extremity. Certain species do not lay eggs, but give birth to living young, as do the plant lice. This abnormal habit is not characteristic of any particular group of forms, but is found with individual species in one or more genera. The young on hatching from the eggs are active, six-legged, mite-like creatures which crawl rapidly away from the body of the mother, wander out upon the new and tender growth of the tree, and there settle, pushing their beaks through the outer tissue of the leaf or twig and feeding upon the sap. Even in this early stage the male insect can be distinguished from the female by certain differences in structure. As a general thing, the female casts its skin from three to five times before reaching the adult condition and beginning to lay eggs or give birth to young. With each successive molt the insect increases in size and becomes usually more convex in form. Its legs and antennæ become proportionately reduced, and its eyes become smaller and are finally lost. As a general thing, it is incapable of moving itself from the spot where it has fixed itself after the second molt, although certain species crawl throughout life. The adult female insect, then, is a motionless, degraded, wingless, and, for all practical purposes, legless and eyeless creature. In the armored scales she is absolutely legless and eyeless. The mouth parts, through which she derives nourishment, remain functional, and have enlarged from molt to molt. Her body becomes swollen with eggs or young, and as soon as these are laid or born she dies.

The life of the male differs radically from that of the female. Up to the second molt the life history is practically parallel in both sexes, but after this period the male larva transforms to a pupa, in which the organs of the perfectly developed, fledged insect become apparent. This change may be undergone within a cocoon or under a male scale. The adult male, which emerges from the pupa at about the time when the female becomes full grown, is an active and rather highly organized creature, with two broad, functional wings and long, vibrating antennæ. The legs are also long and stout. The hind wings are absent, and are replaced by rather long tubercles, to the end of each of which is articulated a strong bristle, hooked at the tip, the tip fitting into a pocket on the hind border of the wings. The eyes of the male insect are very large and strongly faceted. The mouth parts are entirely absent, their place being taken by supplementary eye spots. The function of the male insect is simply to fertilize the female, and it then dies. The number of generations annually among bark lice differs so widely with different forms that no general statement can be made.

CLASSIFICATION.

All Coccidæ are divided into five subfamilies. The species most commonly met with in this country belong to three of these subfamilies, and the majority of them to one, viz, the Diaspinæ—the armored, or shield-bearing, bark lice. These insects, as their name indicates, are all protected by a shield-like covering, which is composed of wax secreted from the back of the insect. This shield, with the adult insects, becomes more or less completely detached from the body, and forms a perfect covering, not only for the body, but, in the case of the female, for her eggs. The insects of the other principal subfamily, but two species of which will be considered here, may be familiarly known as naked scales, and the subfamily group name is Lecaniinæ. These insects are sufficiently characterized for our present purpose by the absence of the scale just mentioned.

SPECIES TO BE CONSIDERED.

Eight species will be treated in this article, and these comprise all of the forms which are especially destructive to deciduous fruit trees in the United States. They are the scurfy bark louse (*Chionaspis furfurus*, Fitch), the oyster-shell bark louse (*Mytilaspis pomorum*, Bouché), the San Jose, or pernicious, scale (*Aspidiotus perniciosus*, Comstock), the walnut scale (*Aspidiotus juglans-regiæ*, Comstock), the greedy scale (*Aspidiotus camelliæ*, Signoret=*rapax*, Comstock), the West Indian peach scale (*Diaspis lanatus*, Morgan & Cockerell), the peach Lecanium (*Lecanium persicæ* Modeer), and the plum Lecanium (*L. prunastri*, Fonsc.). The illustrations given under the specific consideration of each insect will, it is hoped, render them recognizable; but to further assist the use of the following synoptic table is recommended:

A. Insect covered with a scale; nearly flat.
- (*a*) Female scale shaped like an oyster shell.
  - Scale narrow, grayish brown to blackish in color; male and female scales of same shape .... *Mytilaspis pomorum*
  - Female scale broad behind; dirty white or pure white in color; male scale much smaller and with parallel sides .... *Chionaspis furfurus*
- (*b*) Female scale round; male scale shaped like the female, but smaller.
  - Wood of affected new growth or skin of fruit stained about the insect with a reddish color .... *Aspidiotus perniciosus*
  - Wood not stained; scale rather convex, whitish in color .... *Aspidiotus camelliæ*
  - Wood not stained; scale flat, dark gray in color .... *Aspidiotus juglans-regiæ*
- (*c*) Female scale round; male scales white, nearly parallelogrammatic in shape, with a central longitudinal ridge .... *Diaspis lanatus*

B. Insect naked in all stages; not covered with a scale.
  - Brown in color; hemispherical in shape; winters as nearly full-grown female .... *Lecanium persicæ*
  - Winters as larva .... *Lecanium prunastri*

Of these species those found upon apple are *Mytilaspis pomorum*, *Aspidiotus perniciosus*, *A. camelliæ*, and *Chionaspis furfurus.*

The same species are also found upon pear, with the addition of *Aspidiotus juglans-regiæ.*

The species found upon peach are *Aspidiotus perniciosus*, *A. juglans-regiæ*, *Diaspis lanatus*, and *Lecanium persicæ.*

The same species are found upon nearly all varieties of plum.

The species found upon cherry are the same as those found upon apple, but they affect the cherry more rarely.

The quince scales are practically identical with the apple scales, and the apricot scales with the peach scales. Upon quince occurs another species which does not receive specific treatment in this article on account of its comparative rarity, viz, *Aspidiotus cydoniæ.*

NATURAL ENEMIES OF SCALE INSECTS.

Outside of predaceous and parasitic insects, scale insects have few natural enemies. Some years ago there appeared in an English journal the statement that mice had cleared the peach Lecanium from some climbing peach trees trained against the side of a house in England, and in South Africa there is a little bird known as the white-eye (*Zosterops capensis*) which has achieved a reputation as a scale destroyer, but confines itself to the larger species, such as the Lecaniums, the fluted scale, and the like. Among insects there are many species which prey upon bark lice, and their work is undoubtedly of great value. It is their work which unquestionably holds many species of scale insects down to comparatively uninjurious numbers, but when we have said this we have said the larger part of what can be said in their behalf. The ideas of the value of natural enemies which have become prevalent since the introduction of *Vedalia cardinalis* from Australia into California to feed upon the fluted scale are in a measure exaggerated, and it is not likely that another equally successful instance of the practical handling of natural enemies will soon be brought about. It is true that late reports from California show that one of the ladybirds imported by Mr. Koebele on his second Australian expedition is doing good work against the black scale of the olive and orange, as well as against the greedy scale and the purple scale of the orange; but it is too early as yet to judge fully of the permanent value of this species, important as it seems at present, while of the dozens of other species imported at the same time none seem to have increased to any very great extent. With the species of scale insects which we shall consider in this article, parasitic and predaceous insects of different kinds undoubtedly limit their increase to a greater or less degree; but the work of these natural enemies is hardly sufficiently marked to justify us in taking them into serious consideration at the present time in discussing remedial measures. It is well, however, to know what they are.

Among the larger ladybirds the most abundant and most active destroyer of the armored scales in this country is the so-called twice-stabbed ladybird (*Chilocorus bivulnerus*). This species extends all over the country, is many-brooded in the South, and frequently multiplies to such an extent as to destroy the majority of the scales on a given tree. It is readily recognized by its glossy black color, with two red spots on the wing covers. The larva is a black, very spiny creature, which is more efficacious in the work of destroying scale insects than is the adult beetle. Other important scale-destroying ladybirds are figured upon Plate XVIII of the Annual Report of the United States Department of Agriculture for 1881–82. There is a group of smaller ladybirds, the work of which has been to a certain extent overlooked in the older works on economic entomology, but which are among the most important. These are the minute species of the genus Scymnus and its allies. An important species which has been found destroying the San Jose scale in the East is *Pentilia misella*, which is illustrated in all its different stages upon Plate I of the Annual Report of the United States Department of Agriculture for 1893. This insect, which is not a member of the fauna of the Pacific Coast, has been sent to Berkeley, Cal., for the purpose of ascertaining whether it will become established there and prove beneficial as a practical enemy of this destructive scale.

The larvæ of Syrphus flies and of lace-winged flies are of some benefit in destroying the newly hatched larvæ of the armored scales and the larger individuals of the naked scales, but their work is of no serious importance.

Concerning the mites we have little definite information. A number of species are always to be seen upon trees affected by scale insects. One form which for many years has been considered a true enemy of the oyster-shell bark louse of the apple, namely, *Tyroglyphus malus*, first described by Dr. Shimer and afterwards referred to by Walsh and figured by Riley, has lately been decided by M. J. Lignières to feed only upon the cast skins and eggshells of the bark louse, and upon these only when they are somewhat moist. M. Lignières, however, describes a mite which he calls *Hemisarcoptes coccisugus*, which attacks the eggs of the oyster-shell bark louse and forms the most formidable enemy of this species in France. Mr. Hubbard mentions several species which feed upon the eggs of bark lice in Florida, one of the most important of which is *Tyroglyphus* (?) *gloverii* Ashm.

A few predaceous bugs also prey upon scale insects, and probably the most important among them are two little Capsids known as *Camptobrochis nebulosus* and *C. grandis*. The latter is figured upon Plate V of the annual report of the Entomologist in the Annual Report of the United States Department of Agriculture for 1892.

A table of the true internal parasites of the species under consideration follows.

Table of parasites of the foregoing species.

Host insects.	Parasites.
Mytilaspis pomorum (Bouché)	Aphelinus mytilaspidis LeB.
	Anaphes gracilis How.
	Aphelinus abnormis How.
	Aphelinus fuscipennis How.
	Chiloneurus diaspidinarum How.
Chionaspis furfurus (Fitch)	Ablerus clisiocampæ (Ashm.).
Aspidiotus camelliæ Sign	Aphelinus fuscipennis How.
Aspidiotus juglans-regiæ Comst	Encyrtus ensifer How.
	Prospalta aurantii (How.).
	Aphelinus diaspidis How.
	Signiphora occidentalis How.
Diaspis lanatus Morg. & Ckl	None.
Aspidiotus perniciosus Comst	Aphelinus fuscipennis How.
	Aphelinus mytilaspidis LeB.
	Aspidiotiphagus citrinus (Craw.).
	Anaphes gracilis How.
Lecanium persicæ Mod	Coccophagus fraternus How.
	Coccophagus ater How.
	Coccophagus lecanii (Fitch).
	Prospalta aurantii (How.).
	Astichus minutus How. (probably secondary).
	Comys fusca How.

The majority of these parasites, when affecting armored scales, feed upon the eggs of the female late in the season and earlier upon her body. The work of the later broods against the eggs is not complete. Thus we have found upon examination of a large number of the scales of the oyster-shell bark louse in late winter and early spring that from 2 to 18 eggs under scales containing parasites escaped destruction, the average number of eggs in uninfested scales being from 65 to 70. In two cases, where a parasite had issued late in the fall, 11 and 5 sound eggs, respectively, were found. In other scales, from which the parasite had not yet issued, sound eggs were found as follows in each of 10 scales, respectively: 2, 3, 4, 7, 10, 12, 14, 15, 17, 18. From these facts it is perfectly obvious that these parasites will not accomplish complete extermination.

THE OYSTER-SHELL BARK LOUSE.

(*Mytilaspis pomorum* Bouché.)

Original home and present distribution.—This is probably the commonest and most widespread, and consequently the best known, of any of the orchard scales. It is found all over the world. It was probably a European insect originally; at all events it was known in Europe

during the last century, and was probably imported into this country on nursery stock by the early settlers. It is found in the United States practically wherever apples and pears are grown, more abundantly at the North than at the South, and has often received treatment at the hands of writers on injurious insects, the most important articles being that by Professor Riley in his Fifth Report on the Insects of Missouri, and that by Prof. J. H. Comstock in the Annual Report of the United States Department of Agriculture for 1880. Actual localities in the United States from which specimens have been received at this office during the last few years are as follows: Bridgewater, N. H.; Norwalk, Conn.; Providence and Kingston, R. I.; Rye, Irvington, Monticello, Ithaca, Roslyn, and Maine, N. Y.; Walnut Hill, Hoppenville, and West Newton, Pa.; La Fayette, Ind.; Champaign, Ill.; Agricultural College, Vogel Center, and Alpena, Mich.; Westfield and Grand Rapids, Wis.; Andersonville, Tenn.; Olden and Louisiana, Mo.; Lawrence and Emporia, Kans.; Wirth, Ark.; Omaha and Nebraska City, Nebr.; Lewiston, Idaho; Pullman, Wash.; San Francisco, Cal.; Baltimore, Lutherville, and Aberdeen, Md.; Washington, D. C.; Alexandria and Arlington, Va.; Liberty and Charleston, S. C.; Atlanta and Lovett, Ga.; Pronto, Ala.

It is impossible, at this late date, to trace with absolute accuracy the course by which the insect has spread over the country. Mr. Enoch Perley, of Bridgton, Me., in a paper written in 1794 and published by the Massachusetts Agricultural Society in 1796, gives the first American account of the insect, and it is impossible to state how far prior to this date the insect was introduced into the New England colonies. In Harris's time it was extremely common in Massachusetts. Fitch, in 1854, showed that it was already abundant throughout most of the Northern States, and quotes from a Wisconsin observer, showing that it was introduced into that State (at Kenosha) in 1840. At the date of Fitch's writing the insect did not appear to have penetrated west beyond the districts bordering upon Lake Michigan. The orchards upon the Mississippi River were free from it, as were those which he examined less than 100 miles west of Chicago. Walsh, writing in 1867, showed that it reached northeastern Illinois about 1852, and thence spread gradually westward and southward, reaching the Mississippi a few years previous to date of writing. Riley, late in 1868, stated that it had invaded Iowa and northern Missouri, but anticipated that it would not spread to the southward. This hope was not well grounded, however, for, as he himself showed in 1872, it had extended south through Missouri and even into Mississippi and Georgia, while toward the west it had made its appearance in several orchards near Lawrence, Kans. At the present time, in several of the Western States, where apple growing is a comparatively new industry, and in certain localities, the oyster-shell bark louse has not yet obtained a firm foothold. Thus Mr. Marlatt states that in 1888 he had not noticed it at Manhattan, Kans.; Mr. Bruner, that it is yet rare in Nebraska; Mr. H. A.

Morgan, that he has not found it in Louisiana, and Mr. Cockerell reports that it has not yet made its appearance in the orchards about Las Cruces, N. Mex. In California it is present, though rare. Professor Popenoe has reported it the present year from Crawford County, Kans.

Food plants.—The insect is found, in the District of Columbia, upon the apple, pear, quince, hawthorn, buckthorn, raspberry, currant, linden, hop tree, bladder nut, horse-chestnut, maple, water locust, honeysuckle, ash, elm, hackberry, cottonwood, willow, poplar, and upon an exotic Amorpha growing in the Department grounds at Washington. Some doubt has been expressed as to the specific identity of the oystershell bark louse upon some of these plants with the species occurring upon the apple, but so careful a student of the Diaspinæ as Prof. J. H. Comstock was unable to find any structural differences. One peculiar difference in habit, however, was pointed out by Professor Comstock, in that, while the male scale is rare upon apple, it is not at all scarce upon the other plants mentioned.

Specimens received at the United States Department of Agriculture indicate that the insect occurs elsewhere in the United States upon the following plants: Apple, pear, plum, wild red cherry, rose, wild grape, spiræa, fig, bittersweet (*Celastrus*), red maple, striped maple, Juneberry, black ash, white ash, white birch, red birch, swamp willow, and poplar.

So long as no valid structural differences can be found between the forms living upon this great range of food plants, they must be considered as all belonging to a single species; but one can hardly avoid the strong suspicion that certain of these forms will not interbreed and that eventually distinguishing characteristics will be found.

In England, according to Mr. J. W. Douglas, this scale is known to occur upon dogwood, plum, currant, heather (*Calluna*), and heath (*Erica*), in addition to apple. In France, as we note from specimens received by Dr. Riley in 1882 from F. Richter, of Montpellier, it occurs upon *Cratægus oxyacantha*, *Cornus sanguinea*, *Ulmus campestris*, and *Lepidium graminifolium*, while Boisduval and Taschenberg record it from dogwood, elm, whitethorn, medlar, and currant. In New Zealand Maskell records it as occurring upon many plants.

Life history and habits.—If, during the winter, one of the female scales be lifted, it will be found to contain the shriveled body of the dead female, under the anterior or more pointed portion, while behind this the yellowish white eggs are thickly massed together back to the extremity of the scale. In number, the eggs under each scale vary in our experience from 42 to 86. The young hatch from these eggs in most of the Northeastern States during the latter part of May or early in June, wander out upon the twigs, and settle at once. With this species the young twigs are generally the only parts of the tree seriously affected. Older twigs, however, are also attacked, and many specimens of the insect

may be found upon the trunk. There is but one annual generation in the North, and, owing to this fact, the leaves are not attacked. The writer does not remember, in fact, to have ever seen specimens of this scale upon the leaves. Upon the fruit it is almost equally rare, although an occasional specimen is found in such a location. At the meeting of the Association of Economic Entomologists in Brooklyn, in August, 1894, Mr. William Saunders exhibited a small green apple which was covered with these scales. This instance was exceptional in the experience of all the entomologists present, but in late September apple skins were received at the Department of Agriculture from Bridgewater, N. H.,

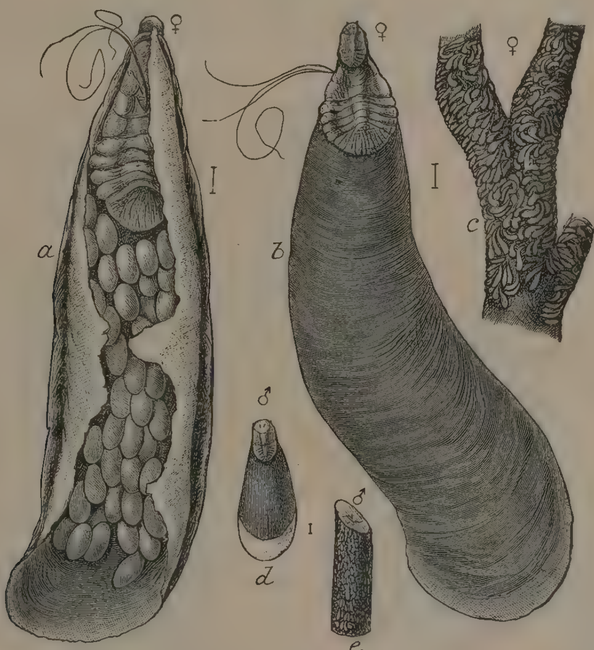

FIG. 26.—*Mytilaspis pomorum*: *a*, female scale from below, showing eggs; *b*, same form above—greatly enlarged; *c*, female scales; *d*, male scale —enlarged (original); *e*, male scales on twig—natural size.

bearing numerous specimens of the scale, and it was noticed later that Dr. Lintner, in his fourth report as State entomologist of New York, mentions having seen a pear bearing specimens of the same. Moreover, Mr. J. W. Douglas, in The Entomologist's Monthly Magazine (XXV, p. 16), records it as met with upon Tasmanian, Canadian, British, and American fruits, though rarely. The interesting point about both these recent American instances is that both were from points far north, and that the occurrence of the scale upon the fruit meant the certain death of the insects and their possible offspring. In the South, however, the insect is two-brooded, and the adults of the first genera-

tion could occur upon the fruit or the leaves without danger, since their offspring could crawl back to the permanent portions of the plant before fall. As a matter of fact, however, we have never seen the insect upon the leaves and very rarely upon the fruit in the South. The question of the single-broodedness of the insect at the North has been doubted by Lintner, on the ground that specimens occurring upon fruit must belong to a second generation; but it seems that they are much more likely to be late hatching individuals of the single generation, although the possibility of an occasional exceptionally warm autumn in which early laid eggs might hatch out of season is not denied.

After inserting its beak and settling, the female molts twice, and begins the formation of the scale, which is secreted mainly from the

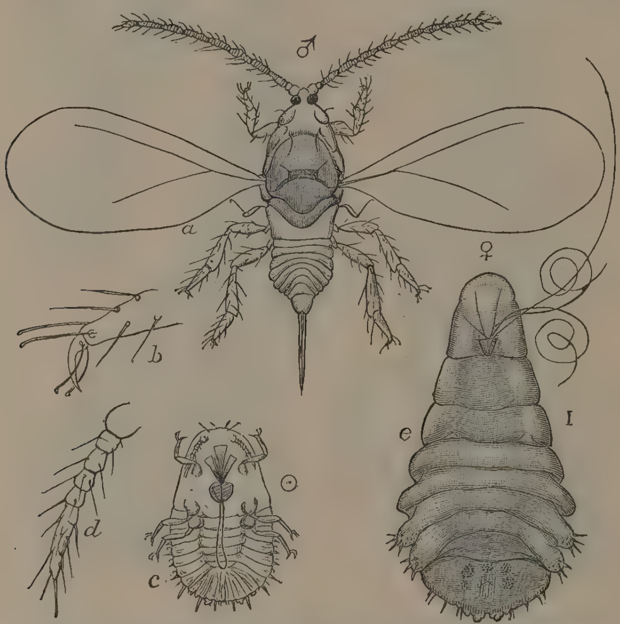

FIG. 27.—*Mytilaspis pomorum:* *a*, adult male; *b*, foot of same; *c*, young larva; *d*, antenna of same; *e*, adult female taken from scale—*a*, *c*, *e*, greatly enlarged; *b*, *d*, still more enlarged (original).

hinder portion of the body and extends backward, the two cast skins remaining in an overlapping position on the anterior portion of the scale.

The male scale is much smaller than the female scale, as indicated in the figures, and is otherwise distinguished by a few structural peculiarities. In the first place, there is but one cast skin at its anterior extremity, and in the next place, the hinder portion of the scale is hinged in such a way that it lifts up like a flap, permitting the escape of the adult male. The different stages and structural details of the insect are so well shown in the figure as to require no further description. The only careful observations as to rate of growth with this species have

been made by Professor Riley, who records, in his First Report on Insects of Missouri, that in Cook County, Ill., the eggs hatch on or about June 6; the females reach full growth August 1, commence to lay eggs August 12, and finish egg laying by August 28. In his fifth Missouri report the same author records the discovery that the species is double-brooded in southern localities. He shows that in Wright County, Mo., the eggs hatch early in May, and makes a Mr. Palmer responsible for the statement that there are two broods, while Dr. Riley himself received hatching eggs from Leake County, Miss., about September 1.

THE SCURFY BARK LOUSE.

(*Chionaspis furfurus* Fitch.)

Original home and present distribution.—Unlike the oyster-shell bark louse, the scurfy bark louse is a native of North America. It has been reported by previous authors from the States of Massachusetts, New York, Pennsylvania, Illinois, Maryland, southern California, and Missouri. It has been sent to the Department of Agriculture from New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, Ohio, Indiana, Iowa, Tennessee, Georgia, Kansas, Nebraska, and South Dakota. It seems, on the whole, to flourish in rather warmer localities than the oyster-shell bark louse. In Missouri Professor Riley records the southward extension of the oyster-shell species into regions previously inhabited only by the scurfy bark louse, and we believe with Walsh that the Mytilaspis is the hardier form of the two, and will, in localities where both species are found, gradually supersede the Chionaspis, just as the purple scale of the orange in Florida has replaced the long scale during recent years, and, as Mr. Cockerell has pointed out, is true with certain West Indian scales. Walsh, in his report as acting State entomologist of Illinois (1867), stated that on all of his apple trees, which were a year or two previously infested by the scurfy scale, the native species was being gradually supplanted by the oyster-shell bark louse, "just," he wrote, "as the white man is supplanting the red man in America, or as in New Zealand the European house fly and the brown Norway rat are driving out the native fly and the native rat."

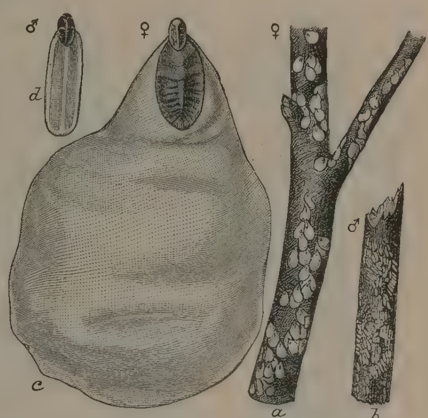

FIG. 28.—*Chionaspis furfurus*: *a*, *c*, females; *b*, *d*, males—*a*, *b*, natural size; *c*, *d*, enlarged (original).

Two years ago the scurfy bark louse was found in England, when Dr. T. A. Chapman took specimens on a red currant bush at Hereford.

Food plants.—The scurfy bark louse occurs abundantly upon apple and pear, and is also found upon crab apple, quince, black cherry, choke cherry, currant, and mountain ash. Upon the last-named plant the writer has seen it occurring so abundantly in the Catskill Mountains that hardly a twig or branch was found uninfested. It has also been received on peach twigs from two localities in Georgia, and occurs abundantly on the Japan quince at Washington.

Life history and habits.—As is the case with the preceding species the female scale, if lifted in the winter, will reveal the shriveled body

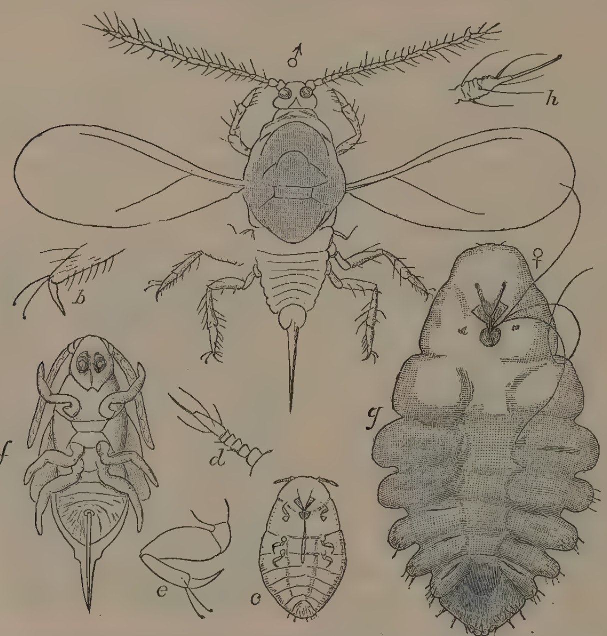

FIG. 29.—*Chionaspis furfurus:* Adult male above; *b*, foot; *h*, tip of antenna of same; *c*, larva; *d*, antenna; *e*, leg of same; *f*, pupa; *g*, adult female removed from scale—all enlarged; *b*, *d*, *e*, *h*, much more than the others (original).

of the insect in front and a mass of eggs behind. The eggs, however, instead of being yellowish in color, as with the preceding species, are purplish-red. The eggs, numbering from 10 to 75 to each scale, hatch quite uniformly about the middle of May in the latitude of Washington, and the life history of the insect is substantially identical with that of the oyster-shell bark louse. The male insect, however, differs quite radically from that of the preceding species in the character of the scale which it forms. This scale, instead of resembling that of the female in color and general shape, is very much smaller, brilliantly white, rather delicate, having nearly parallel sides and three elevated longitudinal ridges, one on each side and one in the center. At the anterior

end the yellowish brown cast skin of the first molt is very evident, through its color contrasting so strongly with that of the scale. There is no record as to the number of generations annually, but, as with the preceding species, there is probably but one at the North, and two, or perhaps more, at the South, as also in California. The collection of the United States Department of Agriculture contains males reared from California scales which issued from August 17 to September 4, and eggs from the same lot of scales which must have been laid about September 1. At Washington the eggs hatch from May 15 to June 1, the males issue during September, and the last females have laid their overwintering eggs by October 15. In Illinois Walsh (Trans. Ills. Hort. Soc. 1867, p. 54) found that the young hatch June 5 to 12, that the mature scale is not formed until about the middle of September, and that the eggs are not laid "until the end of September, or sometimes in October."

THE GREEDY SCALE.

(*Aspidiotus camelliæ* Sign. =*rapax* Comst.)

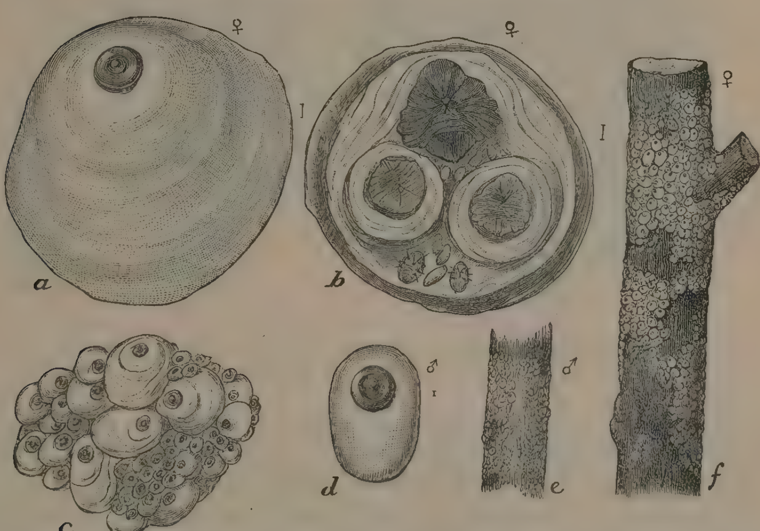

FIG. 30.—*Aspidiotus camelliæ*: *a*, female scale from above; *b*, same from below; *c*, mass of scales as appearing on bark; *d*, male scale; *e*, male scales on twig; *f*, female scabs on twig—*e* and *f*, natural size; *c*, considerably enlarged; *a*, *b*, *d*, greatly enlarged (original).

Original home and present distribution.—The greedy scale was first described in this country by Prof. J. H. Comstock under the name *Aspidiotus rapax* in the Annual Report of the United States Department of Agriculture for 1880, from specimens which he himself collected in California in the spring of that year. It always seemed probable that this was not an indigenous Californian insect, but a good guess could not be made as to its original home until, in 1889, Mr. A. C. F. Morgan

established its identity with the European *Aspidiotus camelliæ*. Under this name, considering it erroneously as identical with one of Boisduval's species, Signoret described this insect as common around Paris. Mr. Morgan records it as abundant in Portugal, and Mr. J. W. Douglas has found it in England. Under the same name Mr. Maskell reports the species as very common in New Zealand, where Mr. Koebele also found it in 1891. It is also recorded as appearing in Australia, in the Agricultural Gazette of New South Wales for September, 1892, in a note by Mr. A. Sidney Olliff. Specimens have also been received from Hawaii. In this country it is found over a wide range of territory on the Pacific Coast, extending north at least to Olympia, Wash., according to Mr. Trevor Kincaid, and south to Guadaloupe Island, off the coast of Lower California. It occurs also in New Mexico and Florida, while Professor Comstock, in the second report of the Department of Entomology, Cor-

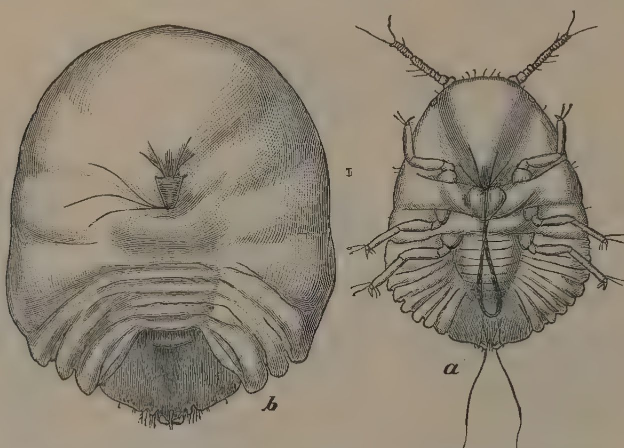

FIG. 31.—*Aspidiotus camelliæ: a*, young larva; *b*, adult female removed from scale and seen from below—greatly enlarged (original).

nell University Experiment Station, for 1883, incidentally mentions that it is found "in hothouses in the North."

From this somewhat complicated geographical distribution the writer is inclined to believe that the species is native to south Europe and has been carried by commerce to Australia and New Zealand, and thence to California, whence it has begun to spread toward the east.

Food plants.—In California Mr. Coquillett has found full-grown specimens of this insect upon the following plants: Apple, pear, loquat, Myosporium, birch, English laurel, maple, South African silver tree (*Leucadendron argenteum*), *Rhamnus croceus*, California walnut, English holly, fuchsia, cottonwood, Japanese camellia, orange, and lemon. Professor Comstock received it in 1880 from Dr. R. S. Turner, who found it upon stems of *Euonymus japonicus* at Fort George, Fla., and himself found it in great abundance and very destructive in California upon

olive, mountain laurel, almond, quince, fig, willow, eucalyptus, acacia, and locust. In Australia Mr. Olliff notes it "chiefly on apple and pear twigs, but sometimes on native plants, such as the black wattle (*Callicoma serratifolia*), and several species of eucalyptus." In France it is found abundantly in the greenhouses in which camellias are grown, and in Portugal it occurs, according to Mr. Morgan, very commonly out of doors and in great abundance on camellias "and other plants." Messrs. Maskell and Koebele state that it occurs on "many trees and shrubs in New Zealand."

During late years we have received it on the fruit of orange and apple from San Diego, Cal., on palm nuts from Guadaloupe Island, and on apple from New Mexico, as well as upon many of the above-mentioned plants from California.

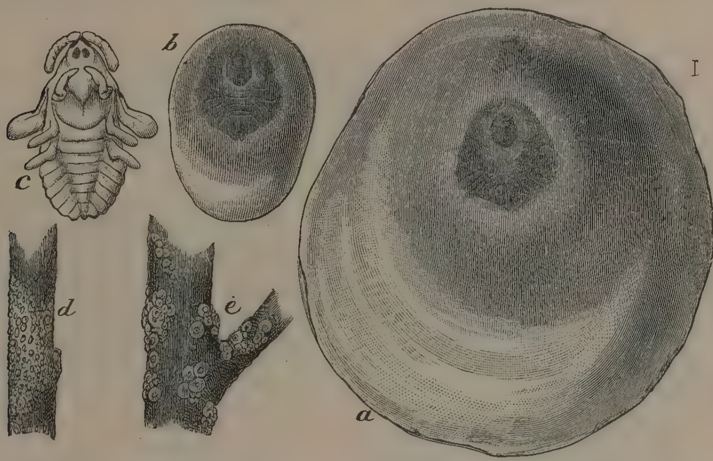

FIG. 32.—*Aspidiotus juglans-regiæ*: *a*, female scale; *b*, male scale; *c*, male chrysalis; *d*, male scales on twig; *e*, female scales on twig—*a*, *b*, *c*, enlarged; *d*, *e*, natural size (original).

Life history and habits.—The adult female scale of this species is very convex, with the exuvia between the center and one side, and covered with secretion. In color the scale is gray and somewhat transparent, so that it has a tendency to appear yellowish when it covers the living female. If the scale be carefully removed from the twig or fruit, a snowy white and usually complete lower scale is found. The insect seems to hibernate indifferently in the egg state, as adult female or as young. The eggs and the newly hatched larvæ are yellow in color. There are no observations upon record which indicate the number of annual generations, and the very fact that the insect passes the winter in several different stages would make such observations very difficult; it also complicates the question of remedies. The insect has, in fact, been studied only in California, and there it may be found in all stages at almost any time of the year.

THE ENGLISH WALNUT SCALE.

(*Aspidiotus juglans-regiæ* Comstock—figs. 32 and 33.)

Original home and present distribution.—This hitherto comparatively rare species was originally described by Professor Comstock from specimens found upon the bark and larger limbs of an English walnut tree at Los Angeles, Cal. In view of the somewhat interesting diversity of food habit, both the specific name and the popular designation which Professor Comstock gave it are unfortunate, as will be shown in the next paragraph. Professor Comstock also recorded the species from New York and the District of Columbia, and it has recently been found by Prof. H. A. Morgan in Louisiana, while Mr. T. D. A. Cockerell has shown that it also occurs at Las Cruces, N. Mex. Twelve years ago specimens were sent to the United States Department of Agri-

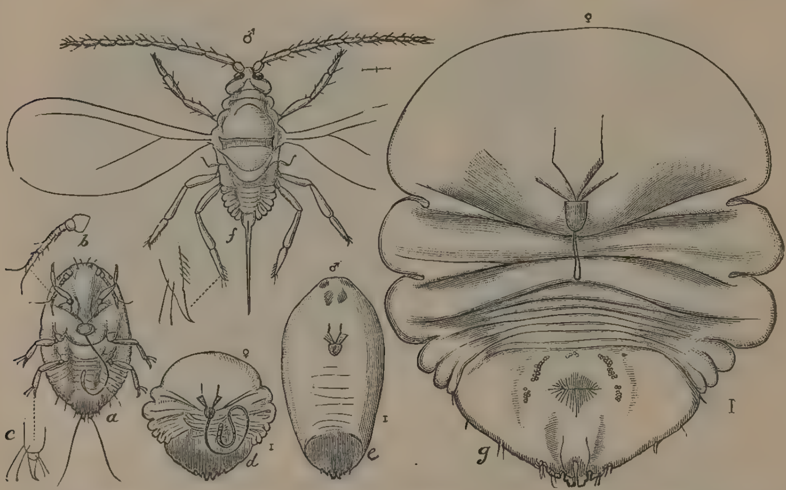

FIG. 33.—*Aspidiotus juglans-regiæ: a*, newly hatched larva; *b*, antenna of same; *c*, foot of same; *d*, female just before last molt; *e*, full-grown male larva; *f*, adult male; *g*, adult female—all greatly enlarged (original).

culture by Mr. H. G. Hubbard, Crescent City, and Dr. J. C. Neal, Archer, Fla., and it has also been received from J. L. Hardy and W. R. Howard, Stuebner and Fort Worth, Tex., and H. Korner, Bay St. Louis, Miss., as well as from F. W. Mally, Dickinson, Tex. The New Mexican specimens are, however, light colored, and among them Mr. Cockerell has found a new variety, which he calls *Aspidiotus juglans-regiæ* var. *albus*. The Florida specimens from Mr. Hubbard are referred to at page 13 of Bulletin 5 of the Division of Entomology (1885) as *Aspidiotus corticalis* Riley MS. It is possible that the eastern and western forms of this species may prove distinct, and that the former will prove synonymous with *Aspidiotus ostreæformis* of Europe, as pointed out by Comstock and Douglas in The Entomologist's Monthly Magazine for March, 1887.

Food plants.—In California the insect has been found only upon English walnut; in New York and the District of Columbia it occurs upon pear, cherry, and locust; in Florida, upon peach and wild plum; in New Mexico, upon ash, pear, apple, apricot, and plum; in Texas, upon peach; and in Louisiana, upon peach and Japan plum. Concerning the Louisiana occurrence, Professor Morgan wrote that the insect was new to fruit growers about Baton Rouge and is doing considerable damage. In Mississippi it occurs on pear and peach, as also in Texas.

Life history and habits.—The female scale resembles that of the other species of the genus, with the exuvia one side of the center. It is a pale grayish brown in color, with the exuvial spot pink or reddish brown. There is no complete ventral scale, such as *A. rapax* has. The color of the full-grown female found under the scale is pale yellow, with irregular orange-colored spots. The scale of the male resembles that of the

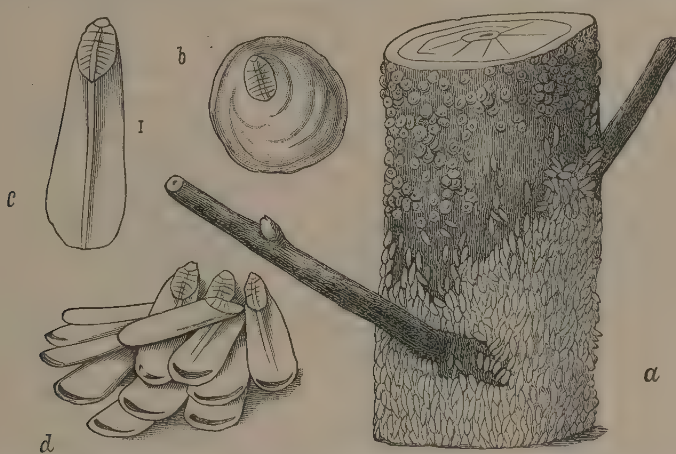

FIG. 34.—*Diaspis lanatus*: *a*, branch covered with male and female scales—natural size; *b*, female scale; *c*, male scale; *d*, group of male scales—enlarged (original).

female in color, and with the male there is a rudimentary ventral scale. No definite observations are on record regarding the number of generations or the method of hibernation. The office notes are not full, and simply show that in Florida adult females were taken under the scales in January, males issued June 1, and eggs were found June 15, which hatched June 18. Specimens received June 12 and 18, from New Mexico and Louisiana, were all full-grown or nearly full-grown females, as were also specimens received from Texas September 4. There must be several annual generations, probably about three, and the adult female hibernates.

THE NEW PEACH SCALE.

(*Diaspis lanatus* Morgan & Cockerell—figs. 34-37.)

Original home and present distribution.—In all probability the original home of this species is the West Indies. It has been found in Jamaica by Mr. Cockerell and his correspondents, in Trinidad by Mr. F. W. Urich,

in Martinique by Mr. E. G. Nolet, on the island of Grand Cayman by Mr. H. McDermott, and in Barbados and San Domingo by Professor Riley. It also occurs in Ceylon, and what is probably this species has been received from Japan. In this country the insect is known to occur in an orchard at Molino, Fla., and in another at Bainbridge, Ga. It was first discovered in this country on some young seedling peach trees in the grounds of the United States Department of Agriculture at Washington in 1892. As is shown in Insect Life (Vol. VI, No. 4), efforts were made to learn the origin of the insect upon these trees, but these efforts were unsuccessful. In the fall of 1894, however, it was discovered that the same insect was to be found upon isolated peach trees in dooryards (usually in back gardens) in many parts of Washington. Old trees were found to be affected in such a way that the insect must have been present in the District of Columbia, although not observed by entomologists, for a number of years. Its presence upon seedlings in the grounds of the Department, then, is probably due to the chance introduction of young larvæ by means of birds or winged insects. The fact that in the three localities in the United States, as well as in the single locality in Ceylon, the insect seems very restricted in its range of food, as well as in its geographical range, while in the West Indies it is widespread and possesses many food plants, seems to indicate, without much doubt, that the species belongs to the West Indian fauna.

FIG. 35.—*Diaspis lanatus*: adult female removed from scale—greatly enlarged (original).

Food plants.—In the District of Columbia the insect is found only upon peach. In Florida and Georgia it has been found upon peach and plum. In Ceylon it occurs upon geranium; in Jamaica, upon grape, bastard cedar (*Guazuma ulmifolia*), *Cycas media*, capsicum, *Argyreia speciosa*, the bark and twigs of an undetermined malvaceous plant, *Bryophyllum calycinum*, peach, Pelargonium, Jasminum, stems of cotton, *Calotropis procera* (French cotton), and *Hibiscus esculentus*. On the

island of San Domingo Professor Riley found it abundantly upon Zizyphus, and in Barbados he collected it upon Cycas.

Life history and habits.—During winter this insect is found in Washington, D. C., only in the condition of the mature female. The eggs are deposited early in May, and the young larvæ hatch by the middle of the month. The males begin to issue the middle of June and impregnate the females, and the latter begin egg laying by the end of the month. The second generation is full grown by the middle of August, and the third egg laying begins at this time. In this latitude the development is comparatively regular.

The scale of the adult female is gray in color, and is not readily distinguished. It occurs abundantly, upon larger twigs than is customary with other scale insects, and frequently appears to be almost covered by the outer bark of the twig. The males have a white scale and, as a rule, cluster on the lower parts of the branches of young trees and at

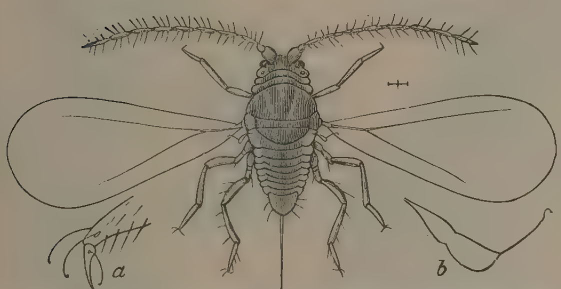

FIG. 36.—*Diaspis lanatus:* adult male—greatly enlarged, with tarsus at *a* and poiser at *b* still more enlarged (original).

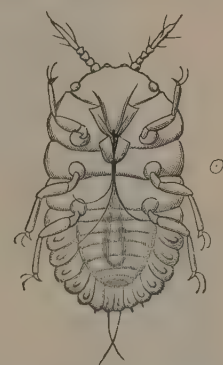

FIG. 37.—*Diaspis lanatus:* larva—greatly enlarged (original).

the base of the trunk. Where the insect is abundant the trees frequently appear as though whitewashed, from the masses of these male scales.

THE SAN JOSE, OR PERNICIOUS, SCALE.

(*Aspidiotus perniciosus* Comstock.)

Original home and present distribution.—The original home of this important scale insect is still in doubt. It has been supposed that it came to America from Chile, but recent investigations by the writer seem to show that it was taken to Chile from the United States. It occurs in Hawaii, but it was brought to this point also from California. It made its first appearance near San Jose, Cal., twenty years ago, at a time when many trees were being imported from many parts of the world. It may have come from Australia, since it is known to occur there, though rarely, or it may have come from some Pacific island or possibly even from China. It has been carried north to British Columbia

and has extended by natural spread eastward to Idaho on the north, and Nevada, Arizona, and New Mexico on the south. Chance importation of California nursery stock has within the past few years resulted in its establishment at many points in the East, and particularly in the States of New Jersey, New York, Pennsylvania, Delaware, Maryland, Ohio, Indiana, Virginia, Georgia, Alabama, Louisiana, and Florida.

Food plants.—This species is a rather general feeder. Fortunately it does not seem to attack citrus trees, but it is found upon almost every variety of deciduous fruit trees. In California it has a very long list of food plants, including with the above, among plants of economic impor-

FIG. 38.—*Aspidiotus perniciosus* on pear fruit and twig, with enlarged male and female scales (original).

tance, the apricot, prune, almond, and English walnut, and Euonymus, rose, and other ornamental shrubs. In the East its principal damage has been done to pear and peach. It occurs, however, in abundance upon apple, plum, cherry, persimmon, and currant, as well as upon Japanese quince, and in one remarkable instance it has been found in great numbers upon a young elm, which was brought from France accidentally with some young pear trees and was planted in a nursery close to some young stock affected with the San Jose scale. There seems to be a marked selection of varieties by the scale. The Bartlett and Duchesse d'Angouleme are almost invariably seriously affected, while

the Kieffer is practically exempt. In New Jersey Professor Smith has found that the varieties affected range in about the following order: Idaho, Madame Van Garber, Lawson, Seckel, Lawrence, and Bartlett Kieffers alone, in his experience, are absolutely exempt, and the Leconte is also nearly exempt. One tree which he especially mentions, and which the writer has had the pleasure of examining, was grafted with Lawson and Kieffer, and the Lawson branch and fruit were covered with scales, while the Kieffer was entirely free.

Life history and habits.—The full life history of the insect was not known until the summer of 1894, when the occurrence of the scale in the East gave opportunity for a careful series of observations in the Insectary of the Department of Agriculture. From these observations it appears that the insect is viviparous, i. e., gives birth to living young and does not lay eggs. It passes the winter as a half-grown or nearly full-grown female. About the middle of May the female begins giving birth to living young, and continues to do so, day after day for six weeks. As soon as the young larva is hatched, it wanders about until it reaches a favorable spot, when it settles, and within forty-eight hours begins the secretion of its scale. This secretion is white and fibrous, and the insect becomes invisible in about two days. At thirty days the female becomes full grown, the males having issued at twenty-four days. At about forty days the females begin to give birth to young. The constant daily birth of the young insects gives rise to a great confusion of generations, which renders observations upon the life history of the species extremely difficult, and only to be accomplished by the isolation of individuals. It also seriously complicates the matter of summer remedies, as a spraying operation at any given time will destroy only those larvæ which happen to

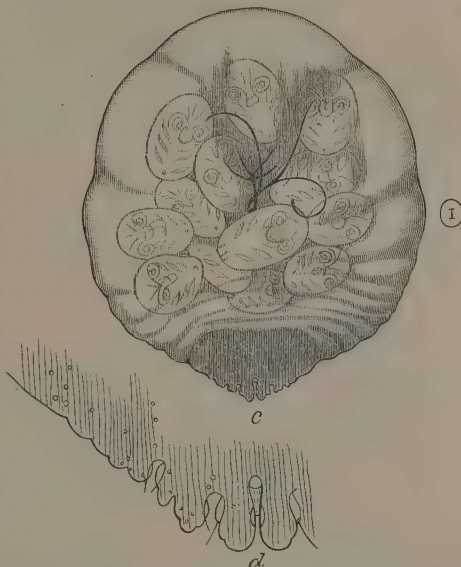

FIG. 39.—*Aspidiotus perniciosus:* c, adult female removed from scale, showing embryonic young—greatly enlarged; d, anal plate—still more enlarged (original).

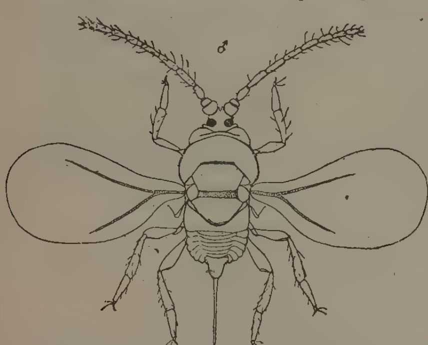

FIG. 40.—*Aspidiotus perniciosus:* adult male—greatly enlarged (original).

be at that particular time less than three days old. The young larvæ are not great travelers and seldom wander more than a few inches. There seem to be in the latitude of Washington five generations annually.

As indicated in the little analytical table of the species considered in this article, the San Jose scale differs from all others in the peculiar reddening effect which it produces upon the skin of the fruit and of tender twigs. This very characteristic feature of the insect's work renders it easy to distinguish. Around the margin of each female scale is a circular band of this reddish discoloration, and the cambium layer of the young twigs, where the scales are massed together, frequently becomes deep red or purplish. When occurring in winter in large numbers upon the bark of a twig, the scales lie close together, frequently overlapping, and are at such times difficult to distinguish without a magnifying glass. The general appearance which they present is of a grayish, very slightly roughened, scurfy deposit. The rich

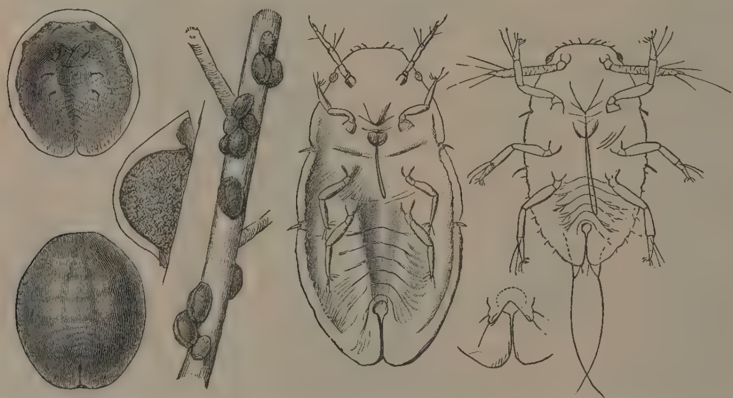

FIG. 41.—*Lecanium persicæ:* Newly hatched larva at right; unimpregnated female next; twig with full-grown females next; female form above and below and cut longitudinally—all enlarged except specimens on twig (original).

natural reddish color of the twigs of peach and apple is quite obscured when these trees are thickly infested, and they have then every appearance of being coated with lime or ashes. Even without a magnifying glass, however, their presence can be readily noted if the twig be scraped with the finger nail, when a yellowish, oily liquid will appear, resulting from the crushing of the bodies of the insects.

A more detailed account of the life history of the insect will be found in Insect Life (Vol. VII, No. 4).

THE PEACH LECANIUM.

(*Lecanium persicæ* Modeer—figs. 41 and 42.)

Original home and present distribution.—This insect is European in its origin. Its natural history was detailed at some length one hundred and fifty years ago by Réaumur, and it has since been mentioned many times by European authors. It is at present widespread in this country, but the date and manner of its introduction can not be definitely

ascertained. Actual receipt of specimens at the United States Department of Agriculture shows that it occurs at Jamaica, Ithaca, and Shelldrake, N. Y.; Chambersburg, Columbia, Leechburg, and Lancaster, Pa.; Newark, Del.; in many localities in Maryland; Washington, D. C.; Cresson, Va.; Holidays Cove, W. Va.; East Carmel, Ohio; Kirkwood, Mo.; in Jasper and Jefferson counties, Mo.; Mammoth Springs, Ark.; and at Las Cruces, N. Mex. If it occurs elsewhere than in Europe and North America the fact is disguised by synonymy.

Food plants.—As its name indicates, this insect is a specific enemy to the peach. It clusters upon the twigs and smaller limbs of peach trees in such masses as completely to cover the bark, and frequently to cause the death of young trees.

Life history and habits.—As above stated, the life history of the insect was described in some detail by Réaumur. Bouché described the male insect, which he stated was found in April, but Signoret never met with it. The different stages of the insect are well illustrated by the figures, and most of the stages may be found at different times during the summer months. The insect appears to overwinter mainly in the advanced female condition, in which stage it is a hemispherical, slightly elongated, brown, rather hard object, 2.5 to 4 mm. in diameter. During the summer of 1893, at Professor Riley's direction, Miss Murtfeldt, at Kirkwood, Mo., studied the life history to some extent, and her observations are recorded upon pages 41–44, Bulletin 32, of the Division of Entomology, United States Department of Agriculture. She shows that the eggs are fully formed by the 20th of May. They are half a millimeter long, pale yellow in color, and rest free in the mass. The young began to hatch June 10, and continued to hatch for nearly a month. By July 15 hatching was completed, and in the meantime those first hatched, of which part were separated and kept on fresh twigs in a rearing jar, had nearly all become stationary on the leaves and transformed to male pupæ. Twigs from the living tree at this date had the foliage covered with the young in all stages. On the 22d July winged males appeared, the pupal period being about one week. The males remained alive for about a week. Their most striking peculiarity consists in the apparent lack of poisers, or rudimentary hind wings. The female scales were nearly half grown at this time, and later darkened in color, thickened, and became centrally elevated. There seemed to be but a single generation annually, and the best time for remedial work against the young will, therefore, be from the end of the first week in June until a month from that time.

Where the insects crowd the twigs abundantly a perceptible amount of honeydew is found to be excreted. A smut fungus develops upon this honeydew, which eventually covers the scale mass, and many of the scales are destroyed. On one tree which has been under the writer's observation the scales clustered most abundantly on the underside of the twigs. The honeydew secreted by these individuals dropped upon the upper surface of the twigs immediately beneath. This upper sur-

face of the twigs, therefore, while comparatively free from scales, was covered with the fungus, which gradually extended around to the underside and affected the rows of scales, which themselves were dropping honeydew upon other still lower twigs. In October, 1894, it was with difficulty that a single living scale was found, but the entire tree had become greatly enfeebled from their earlier attacks.

THE NEW YORK PLUM LECANIUM.

(*Lecanium prunastri* Fonsc.)

There are certainly three distinct species of the genus Lecanium which affect the plum in the United States. Two of these pass the winter in the flat larval condition, attached to the twigs, and the third hibernates, like the peach Lecanium, as a nearly full-grown, rounded female. One of these three species has, within the last two years, attracted a great deal of attention in western New York, and has done a great deal of damage. It has been decided by Mr. Newstead, of Chester, England, that it is identical with the European species above named. It has been closely studied by Mr. Slingerland, of the Cornell University Experiment Station. From the bulletin which he has published about it, as well as from specimens sent to the writer by New York correspondents, it appears that while the species is quite widely spread throughout New York, it exists at present in alarming numbers only in several large orchards near Geneva, Rochester, and Lockport. In July the young scales hatch, and remain small in size throughout the remainder of the summer, autumn, and winter. They spread out upon the leaves at first, and toward fall return to the branches. In April they resume activity, and soon begin to grow with considerable rapidity. The males and females resemble, in general, the peach Lecanium shown in the figures illustrating the preceding species. About the end of May the females begin to lay their eggs, which hatch, as before stated, about the first of July.

REMEDIES FOR ORCHARD SCALES.

The washes which have been used against scale insects have been almost innumerable. Lye, soda, tobacco water, dry ashes, tar, fish brine, potash, sulphur, common brine, soap, quassia, and aloes solutions, the ammoniacal fumes of sheep manure, and compounds of two, three, and four of these ingredients, were mentioned by Walsh as having been recommended before his time. He proved, by an elaborate series of experiments, that a strong solution of soap will kill the oyster-shell bark louse shortly after it hatches out. Petroleum or kerosene, he stated, would kill the eggs. He further speaks of the experience of many prominent fruit growers of the time, among them that of Mr. J. L. Budd, who had found that ten parts of benzine and four of soap afforded a good remedy against bark lice. Here was evidently an early though imperfect emulsion. The recommendations of Comstock in 1880 followed rather closely the results of California experiments.

His efforts to make a good kerosene-milk emulsion, on the recommendation of Riley in the Scientific American of October 16, 1880, were unsatisfactory. The two remedies which he urged most strongly were, first, whale-oil soap at three-fourths of a pound to a gallon of water, applied warm, and 1 pound of concentrated lye, 1 pint of gasoline or benzine, half a pint of oil, 5 gallons of water. The whale-oil soap he experimented with himself with good success, while of the lye-benzine-kerosene mixture he simply saw the results in the orchard of Mr. V. C. Mason, of California. The scale upon which these experiments were made was the California red scale of the orange. In the Annual Report of the United States Department of Agriculture for 1881–82 Professor Comstock recommended the use of 1 pound of lye to 5 gallons of water, and quoted the experience of S. F. Chapin and Matthew Cooke in support of his recommendation. In the meantime the important work of Mr. H. G. Hubbard in the perfecting of kerosene-soap emulsions against the scale insects of the orchard had been begun under

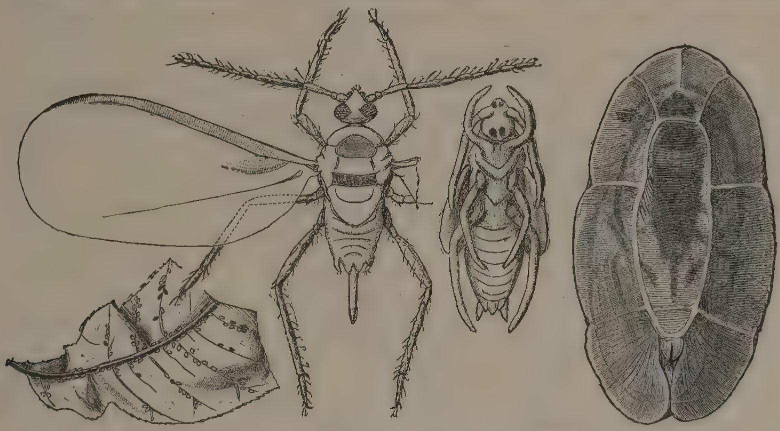

FIG. 42.—*Lecanium persicæ:* full-grown male scale at right; pupa next; adult male next; leaf with young male scales at left—last, natural size, other figures greatly enlarged (original).

the direction of the former entomologist, Professor Riley. These emulsions, and particularly the one which has become adopted under the name "Riley-Hubbard formula," proved in the course of long experience to be perfect destroyers of newly hatched scale insects of all kinds, and, indeed, when the problem simply concerns the destruction of unprotected young we need look for no better or cheaper remedy.

The kerosene emulsions, however, fall short of being perfect scale-insect remedies for the reason that certain scale insects do not give birth to their young at a definite or nearly definite time, and the spraying will have to be repeated frequently as more young hatch. This is particularly the case with the San Jose scale, the new peach scale, and the greedy scale. The desideratum is a wash which by one or at most two applications will kill the insect. The young hatch in the summer time, and applications at this time of the year have to be comparatively weak

in order not to injure the foliage. Winter washes, therefore, are the ones to be desired. In the application of winter washes Californians have had a great deal of experience, but experience in California is not a safe guide for orchardists in the East. The long dry spells in California admit of the application and efficacious work of washes over long periods during which they will not be washed off by rain. This fact operates in the East against the work of resin washes, which have been proved to be efficacious in many cases in California. Moreover, the California winter is much milder than that of our more northern and eastern States and there is no perfect hibernation of scale insects. Their winter dormancy is by no means as complete as it is with the same species in the East. This more perfect dormancy in the East renders the insect much more resistant to the action of washes. From these facts it results that not only are the resin washes of little avail for winter use in the major part of the country, but also that the lime, salt, and sulphur, and lime, sulphur, and blue vitriol washes, so highly recommended on the Pacific Coast, have by no means the same effect east of the Rocky Mountains.

Two of our common orchard scales, viz, the scurfy bark louse and the oyster-shell bark louse, hibernate in the egg state, and their hatching is comparatively uniform. The approximate date throughout the middle belt of the country is from the middle to the end of May. Moreover, the larvæ are comparatively slow to settle, and the scale at first is not very dense. Therefore one, or at the most two, applications of kerosene-soap emulsion, diluted with ten parts of water, made about the first of June, will hold these two species well in check. Both species hibernate in the egg state, and the eggs, particularly of the oyster-shell species, are difficult to destroy. The emulsion spray for the young is, however, sufficiently efficacious, so that the winter wash for the eggs is not necessary.

The same condition of affairs holds to a great degree with the peach Lecanium. Here the insect does not hibernate in the egg state, and a strong winter wash will be more or less efficacious; but as the eggs are laid and the young hatch quite uniformly through June, and as the young do not form scales, the kerosene-emulsion spray will here again prove the best solution to apply.

With the San Jose scale, the greedy scale, and the new peach scale, and possibly with the walnut scale as well, the most satisfactory work can be done only with a winter wash. All of these species may be found in various stages of development at any time through the summer months, and an emulsion spray at any given time will kill only a small proportion. Moreover, with the San Jose scale in particular, the young larva settles almost at once, and immediately begins secreting a dense scale which after forty-eight hours is practically impervious to the ordinary emulsion, diluted so as not to injure the foliage. It is true that from one locality it has been reported to us that a single spraying with the emulsion in June has rid a certain number of trees of the

insect, but in the light of our own experience this seems incredible. On the contrary, we have known during the past summer three sprayings with the emulsion to be made, beginning with the last week in May and covering a period from that time to the end of July, with the result that at the close of the season the trees were almost as badly infested with living insects as they were the previous winter.

The question arises, in the case of these scales, What winter wash shall be applied? Many different washes, in varying proportions, have been tried with great care during the winter of 1894–95. Up to the present writing but one absolutely satisfactory winter wash against this insect in this locality has been found. This is whale-oil soap, a pound and a half or 2 pounds to the gallon of water. This mixture killed every insect upon the trees to which it was applied, as was proved by a very thorough examination. Good whale-oil soap can hardly be bought for less than 4 cents per pound by the barrel, and this makes satisfactory winter treatment an expensive matter. The best recommendation that can be made from the present outlook, however, is to use this mixture soon after the leaves fall in the autumn, and then, if examination shows any survivors, to repeat it shortly before the buds open in the spring. It is very possible that at these two periods a somewhat weaker wash will suffice, but at the present writing satisfactory experiments in this direction have not been made. A good fish-oil soap may be made at home, which will be almost as satisfactory as whale-oil soap, but it will be found quite as expensive to make it as to buy it.

The New York plum Lecanium may also be best treated by a winter wash, since it hibernates in the perfectly unprotected larval condition. The New York experimenters have found that a kerosene emulsion, in the proportions of one part of the standard emulsion to four parts of water, will answer if it is applied about three times. The recommendation is to spray once before winter closes in, and again in the spring, before April 1. If possible, spray also once during the interval.

To recapitulate: From our present information the best results in the Eastern States against San Jose scale, the West Indian peach scale, the greedy scale, and the walnut scale will be obtained by the thorough application of a fish-oil or whale-oil soap solution at the rate of 2 pounds to a gallon of water. The application should be made soon after the leaves fall in the autumn.

For the oyster-shell bark louse, the scurfy louse, and the peach Lecanium, one or two applications of kerosene-soap emulsion, diluted one part to ten of water, from the first to the last of June, will kill the young lice and prevent undue increase of the species.

The gas treatment, which has been frequently mentioned in the publications of the Division of Entomology, United States Department of Agriculture, will seldom be used in the East. It was tried in the spring of 1894 at Charlottesville, Va., against the San Jose scale. The California method, as adopted by Mr. D. W. Coquillett at Los Angeles, was

used. The operation was at first supposed to be perfectly successful, but in the fall of 1894 a few scales were found to have escaped suffocation. Moreover a certain number of the trees were injured more or less seriously by the operation. The only use which Eastern fruit growers will have for the gas treatment will probably be in the fumigation of affected nursery stock. The process is described in Farmers' Bulletin No. 19 of the United States Department of Agriculture.

PREVENTIVES—INSPECTION AND QUARANTINE LAWS.

One who has read the foregoing account of our eight principal scale-insect enemies to deciduous orchard trees can not fail to be impressed by the unrestricted ease with which these insects are spreading and have spread through the country. Orchardists do not seem to have examined new nursery stock, and by this neglect have laid the foundation for great future damage, not only to their own tree property but to that of their entire neighborhood. Nurserymen seem to have been equally careless in sending out stock without prior examination or treatment. Moreover, five of the eight species mentioned have been imported from abroad. In the Eastern and Mid-western States there are absolutely no restrictions to the free spread by commerce of injurious insects of all kinds. California, a number of years ago, saw the danger in unrestricted commerce in fruits and nursery stock. She established a horticultural commission and her legislature passed a wise law, which, if perfectly enforced, would protect that State in large degree from such evils. Her example has been followed by Oregon, Washington, Idaho, and Colorado. British Columbia has lately enforced such regulations, and several of the Australian colonies, as well as New Zealand, have put in operation legal regulations which will bring about the desired result. Agricultural and horticultural societies are beginning to agitate the question of protection in the Eastern States. The United States Department of Agriculture has just issued a bulletin (No. 33 of the Division of Entomology) in which the insect laws of the Western States have been brought together. Using any of these laws as a guide, committees of State horticultural societies can draft resolutions calling upon State legislatures for action in this direction.

In the meantime all persons purchasing nursery stock are advised to require, from the dealers from whom they purchase, guaranties as to the freedom of the stock from injurious scale insects at least; and it is further advised that nurserymen take such measures as will enable them advisedly to give such guaranties. The nurseryman who first advertises that all of the nursery stock which he sends out has been thoroughly fumigated with hydrocyanic-acid gas, or who can furnish a certificate from his State entomologist as to the freedom of his establishment from injurious insects, will not only have done a good stroke of business directly, but will have the prestige of a pioneer in a wise and patriotic movement.

THE MORE IMPORTANT INSECTS INJURIOUS TO STORED GRAIN.

By F. H. CHITTENDEN,
Assistant Entomologist, U. S. Department of Agriculture.

After the grain has escaped the ravages of its many insect enemies in the field, and is harvested and in the bin, it is subject to the attack of insects of several species popularly known as weevils.

The experience of many years, including the present, shows that there is great need among farmers and others of information in regard to the insects that are destructive to stored grain, and of the measures that may be employed for protection and remedy against them. To supply this want is the object of the present article. In its preparation published information has been drawn upon, and there have been incorporated new data from the records of this division and from personal observation and experiment. Technical matter has been excluded, and with the aid of the accompanying illustrations and simple descriptions the intelligent farmer, miller, or merchant who handles grain, will be able to recognize the different grain-feeding species in their various stages, and with the brief accounts given of their habits and the nature of their injuries will be prepared to guard against these insects and to destroy them when present in the granary, mill, or storehouse.

Of the two score species of insects of most common occurrence in stored cereals and cereal products, there are three that live in their adolescent stages entirely within the kernel or grain. These are the granary weevil, rice weevil, and Angoumois grain moth, the commonest and most injurious species, both in America and abroad. The remainder live on grain, both in the kernel and when ground up into flour and meal and feed also on various other stored products.

ORIGIN, INTRODUCTION, AND HABITS OF THE SPECIES.

Of the species known to attack stored cereals in the United States nearly all have been introduced and are now cosmopolitan, having been distributed by commerce to all quarters of the globe. In fact, no insects are more easily carried from one land to another, since they breed continuously for years in the same grain, and are transported when in an immature state in the kernels.

In their native homes in the tropics, and even in our Southern States, these insects live an outdoor life, but in the colder countries of the temperate zone and in our Northern States they lead an artificial

or domestic existence, the beetles, particularly, with few exceptions, passing their entire lives wholly within doors, being, therefore, dependent upon man for their subsistence.

The various species of insects that attack stored grain as well as pease and beans are indiscriminately but erroneously called weevils, or simply "weevil," but the only true grain weevils are the rice weevil and granary weevil.

When it is considered that grain constitutes the chief article of diet of man, and that these insects have found their way to every tropical and temperate region where grain grows, it may be said without fear of contradiction that they are entitled to front rank among noxious insects.

NATURE AND EXTENT OF DAMAGE.

In addition to the loss in weight occasioned by these insects, grain infested by them is unfit for human consumption, and has been known to cause serious illness. Nor is such grain desirable for food for stock. Horses, it has been experimentally proved, are injured by being fed with "weevily" grain, and it is somewhat doubtful if such material is fit even for swine. Poultry, however, feed upon it with impunity. "Weeviled" grain is also unfit for seed stock, as its use is apt to be followed by a diminution in the yield of a crop.

As regards the insect injury to stored grain in this country, one writer has estimated that there is "an annual loss of over $1,000,000 from weevils in Texas alone," and that nearly 50 per cent of the corn in that State is annually destroyed by weevils and rats. Another writer has expressed the opinion that the annual loss to Texas from the injury to grain in the field and in the bins will amount to hundreds of thousands of dollars. The loss from granary insects to the corn crop in Alabama in 1893 was estimated at $1,671,382, or about 10 per cent.

PARASITES AND NATURAL ENEMIES.

It might be supposed that insects which live a retired indoor existence would be comparatively free from parasitic and other enemies, but such is not the case.

It has been estimated of one species, the granary weevil, that one pair in the course of a year would produce 6,000 individuals. The moths are still more prolific, and as there are six or more broods of some species annually, it will be seen that if all the eggs of one individual and her offspring develop there would be produced in one year a whole myriad of the insects, sufficient to destroy many tons of grain.

Fortunately, there are several natural checks to the undue increase of these insects. One of them is a diminutive mite which preys upon various species. The spiders that inhabit mills and granaries entrap the moths, and in the field they are preyed upon by nocturnal insects as well as by birds and bats.

The grain weevils are often parasitized, three or four chalcis flies having been recognized as their enemies. The Angoumois moth has a specific parasite, as has also the saw-toothed grain beetle; two or three parasites are known to prey upon the Mediterranean flour moth; another infests the Indian meal moth and wolf moth, and several other granary insects are known to have parasites.

The good work that is sometimes done by parasites in limiting the multiplication of their grain-feeding hosts is exemplified in a case cited of *Ephestia kuehniella* being destroyed by a parasite when other means had failed to dislodge it in the warehouses which it had invaded.

THE GRANARY WEEVIL.

(*Calandria granaria* Linn.)

The granary weevil is the "curculio" and "weevil" of early writings, and in the Georgics of Virgil there is evidence that the insect and its ravages were known before the Christian era. It is probable that this, as well as some other cosmopolitan species that are generally supposed to have originally inhabited the Orient, is native to the Mediterranean region. Having become domesticated ages ago, it has long since lost the use of its wings, which are present only as mere rudiments and useless as organs of flight. It is strictly a granary insect, and is apparently perfectly naturalized in regions much farther north than are inhabited by the rice weevil.

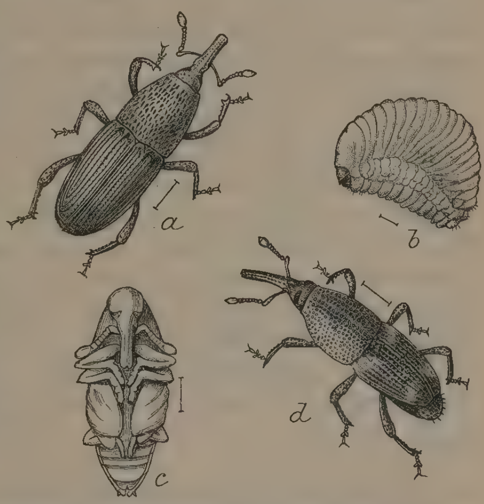

FIG. 43.—*Calandra granaria: a*, adult beetle; *b*, larva; *c*, pupa; *d*, *Calandra oryzæ*, beetle—all enlarged (original).

The adult granary weevil is a small, flattened snout-beetle of the family Calandridæ, measuring from an eighth to a sixth of an inch, being on an average a trifle larger than the rice weevil, from which it differs in being of a uniform shining chestnut-brown color, in having the thorax sparsely and longitudinally punctured, as indicated at figure 43, *a*, and in being wingless. The head is prolonged in front into a long snout or proboscis, at the end of which are the mandibles; the antennæ are elbowed and are attached to the proboscis.

The larva is legless, considerably shorter than the adult, white in color, very robust, fleshy, and of the form shown in the illustration (*b*). The pupa, shown at *c*, is also white, clear, and transparent, exhibiting the general characters of the future beetle.

The female punctures the grain with her snout and inserts an egg, and from this is hatched a larva which devours the farinaceous interior and undergoes its transformations within the hull. In wheat, barley, and other small grains a single larva inhabits a kernel, but a kernel of maize furnishes food for several individuals.

The time required for the completion of the life cycle varies with the season and climate, and the number of generations annually produced is consequently dependent upon temperature. As a result, writings on this subject show a noticeable disagreement. One writer says that the period of development for the rice weevil varies from three to eight weeks, and that there are probably at least eight generations annually. There is one case on record in which, in England, thirteen weeks were consumed in the development of a single generation. The earlier European writers agree that there are but two broods of the granary weevil annually in that quarter. It is not probable that there is much variation in the development of these two species. The writer has carried both species through from egg to adult in shelled corn in forty-one days, or about six weeks, but it is possible that under exceptionally favorable conditions this period may be somewhat shorter. There are probably four or five broods in this latitude and six or more in our Southern States.

The chief injury done by the granary weevil is to wheat, maize, and barley, but it also attacks other grains and is very partial to pearl barley and to the chick-pea (*Cicer arietinum*), a leguminous seed cultivated for food in the tropics.

Unlike the moths which attack grain, the adult weevils feed also upon the kernels, gnawing into them for food and for shelter, and, being quite long lived, probably do even more damage than their larvæ.

The writer has kept the beetles alive for several months, and others claim to have kept individuals under observation for upward of a year. Egg laying continues over an extended period, and it will be seen that a single pair and their progeny are capable in a short time of causing considerable mischief.

THE RICE WEEVIL.

(*Calandra oryza* Linn.)[1]

The rice weevil derives both its popular and Latin name from rice (oryza), in which it was first found by its discoverer. It is conceded to have originated in India, whence it has been diffused by commerce until it is now established in most of the grain-growing countries of the world. There is no record of the occurrence of this insect in Europe earlier than 1763, when the species was described by Linnæus, but it was probably imported into southern Europe many years prior to that time. From Europe it was introduced into America, and at the present

[1] The specific name of the rice weevil has uniformly been spelled "*oryzæ*" by all writers since the time of Linnæus, but the original spelling is *oryza*. (See Amœn Acad., Vol. VI, p. 395.)

time is as widely distributed and injurious as any known insect. It is a serious pest in the Southern States, where it is commonly, though erroneously, known as "black weevil," but farther north it is of less importance. It occurs, however, in every State and Territory in the Union and occasionally invades Canada and Alaska.

In olden times long voyages were necessary in importing grain from the East, and damage by the rice weevil, when whole cargoes were often lost, was much heavier than at present. But the losses occasioned by this insect are still enormous, particularly in India, Mexico, South America, and other tropical countries.

The rice weevil resembles the preceding species in size and in general appearance. It is dull brown in color; the thorax is densely pitted with round punctures; the elytra, or wing cases, are ornamented with four more or less distinct red spots, arranged as in the illustration (fig. 44, *d*), and it has well-developed and serviceable wings. The larvæ and pupæ are also similar to those of the granary weevil, and in habits and life history it does not differ materially from that species.

The question whether or not this insect ever lays its eggs in grain in the field has been the occasion of some discussion and of unsatisfactory experiment abroad, but we have the testimony of several experienced entomologists that the insect is of very common occurrence in grain fields in the South, remote from granaries.

Although the rice weevil feeds upon the grain of rice, it thrives equally well, seemingly better, on wheat, particularly the soft varieties, and on maize. It also breeds freely in the cultivated varieties of sorghum (*Andropogon sorghum*), known variously as Guinea corn, Kaffir or Jerusalem corn, millet, etc.; in barley, rye, hulled oats, buckwheat, chick-peas, and Job's tears (*Coixa lachryma*). Unhusked rice is particularly exempt from its attacks, and the husk of oats similarly protects this cereal. Corn in the ear and unhulled barley are not so exposed to infestation as the shelled or hulled seed, but are by no means exempt, as has been stated by some writers.

The adult beetles attack a great variety of food products not affected by the larvæ. When abundant in storehouses and groceries they invade boxes of crackers, cakes, yeast cakes, macaroni, and other breadstuffs, barrels and bins of flour and meal, and can subsist for months on sugar. They are even said to burrow into ripening and overripe peaches, grapes, and mulberries, and to attack hemp seed, chestnuts, and table beans.

THE ANGOUMOIS GRAIN MOTH.

(*Gelechia cerealella* Ol.)

The Angoumois grain moth derives its name from the province of Angoumois, France, where it is said to have been injurious for nearly a century and a half. It probably originated, with the granary weevil, in the Mediterranean region, and possibly in southern Europe. In this country it is familiarly but incorrectly called the "fly weevil."

The history of this insect in Europe dates back to 1736, when Réaumur found it damaging stored barley in France, but the moth was not described until 1789. In America an account by Col. Landon Carter, published in 1771, brought out the fact that injuries from this species began in North Carolina as early as 1728.

From the seat of its original introduction this moth has spread to neighboring States in the South, where it does incalculable damage, and to the southern portions of the Northern States, where it is less injurious. It is occasionally troublesome as far north as Canada, and has been reported as doing serious damage in Australia and India. The work of the writer at the Columbian Exposition would indicate that it has now become cosmopolitan, as it was found there in a majority of the cereal exhibits of the tropical and warmer temperate countries.

In Europe the favorite food of the Angoumois moth is said to have been barley; in America its chief injury is to corn and wheat, but it infests also all the other cereals, as well as buckwheat, chick-peas, and, it is said, cowpeas. It has been estimated that in six months grain infested by this moth loses 40 per cent in weight and 75 per cent of farinaceous matter. In addition to the loss in weight, the grain is totally unfit for food, and it has been said that bread made from wheat injured by this moth was the cause of an epidemic in certain regions of France infested by the species.

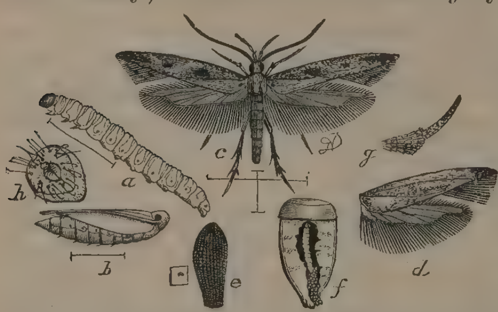

FIG. 44.—*Gelechia cerealella: a*, larva; *b*, pupa; *c*, ♀ moth; *e*, egg; *f*, kernel of corn opened, showing larva feeding; *h*, anal segment of pupa—all enlarged except *f*. (From Riley in Ann. Rept. Dept. Agr., 1884.)

This insect is a small moth of the family Gelechiidæ and resembles somewhat our familiar clothes moths, for which species, indeed, it is often mistaken. It is light grayish brown in color, more or less lined and spotted with black, and measures across the expanded fore wings about half an inch (see fig. 44, *c*). The hind wings are bordered with a long, delicate fringe.

The moth normally deposits its eggs in standing grain, singly or in clusters of from 20 to 30. The eggs, shown at figure 44, *e*, are red in color and hatch in from four to seven days, when the minute caterpillars burrow into the kernels and feed on the interior. A single larva inhabits a grain of the smaller cereals, but in maize sustenance is afforded for two, three, or more individuals. Figure 45 represents an ear of pop-corn infested by this moth. In about three weeks' time the caterpillar attains full growth (see fig. 44, *a*), when, without leaving the kernel, it spins a thin, silken cocoon in which it transforms to a

chrysalis (fig. 44, *b*), the moth emerging a few days later, the entire period from egg to adult embracing in summer from four to five weeks. After copulation, the moth soon deposits her eggs for another brood, and in this manner several generations of the insect are produced in the course of a year. The older writers believed that the species was normally double-brooded, but as the insect breeds continuously in the harvested grain, there is now an irregular development which is influenced by temperature. In this latitude there are probably five or six generations annually. Mr. H. E. Weed estimates that in the warmer climate of Mississippi, where the insect can breed uninterruptedly during the winter months, there are at least eight generations.

In some respects the Angoumois grain moth is more troublesome than any of the other granary insects. Even as far north as central Pennsylvania it lays its eggs on grain in the field, and it is, therefore, impossible to entirely prevent infestation.

The custom of leaving the harvested grain in stack in the field for weeks before thrashing, in vogue in some parts of our country, is the cause of perhaps the greatest proportion of infestation. The introduction of the insect into the granary through this channel may be practically prevented in the case of the smaller cereals by harvesting and thrashing as soon as possible after the grain reaches maturity. If, after the removal of the old grain from bins, these are thoroughly cleaned and fumigated before the introduction of fresh grain, the chances of injury are reduced to a minimum.

This, as well as the other granary moths is soft, delicate, and easily crushed, and is unable, when buried beneath a large mass of grain, to extricate itself; hence storing the grain in bulk and stirring, shoveling, or agitating by other means is productive of the best results with this insect.

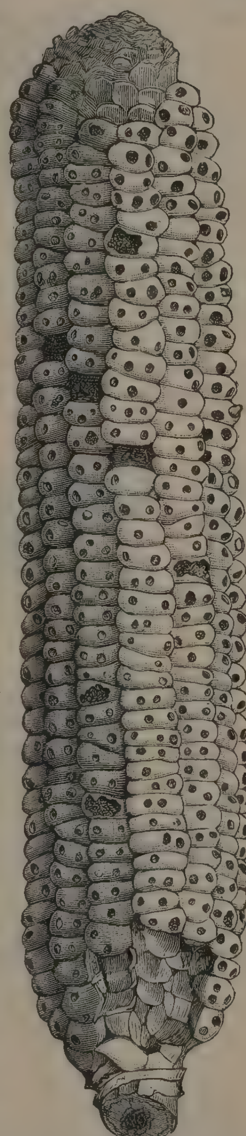

FIG. 45.—Ear of pop-corn showing work of Angoumois grain moth. (From Riley in Ann. Rept. Dept. Agr., 1884.)

THE MEDITERRANEAN FLOUR MOTH.

(*Ephestia kuehniella* Zell.)

This scourge of the flour mill, as it is called, has attracted much attention of recent years and has been the subject of many articles and bulletins. Until the year 1877, when the moth was discovered in a

flour mill in Germany, it was comparatively unknown. In later years it invaded Belgium and Holland, and in 1887 appeared in England. Two years later it made its appearance in destructive numbers in Canada.

That the Mediterranean flour moth has become so formidable in recent years is due to the higher and more equable temperature maintained in modern mills, a condition highly favorable to the development of the insect.

Previous to the Canadian invasion this moth was generally believed to have reached Europe from America, but, as a matter of fact, the species had not been recognized here until 1889. Danysz has traced its occurrence in this country back as far as 1880. He mentions also an outbreak in Constantinople in 1872 and presents evidence that it was probably known in Europe as early as 1840. Until the present year this insect was known as injurious on this continent only in Canada and California, but in the American Miller of May 1, 1895, Mr. W. G. Johnson states that it has appeared in New York State. It is recorded also from North Carolina, Alabama, New Mexico, Colorado, Mexico, and Chile, and probably occurs in Australia.

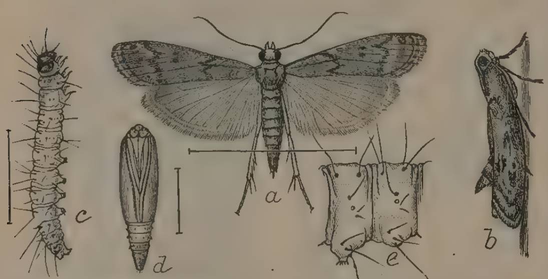

FIG. 46.—*Ephestia kuehniella:* *a*, moth; *b*, moth, from side, resting; *c*, larva; *d*, pupa—enlarged; *e*, abdominal joint of larva—more enlarged (*b*, *c*, *e*, from Insect Life; *a* and *d*, original).

The adult moth has a wing extension of a little less than an inch; the fore wings are pale leaden gray, with transverse black markings of the pattern shown in the accompanying illustration (fig. 46, *a*); the hind wings are dirty-whitish, semitransparent, and with a darker border. The caterpillar is illustrated at *c*, *e*, and the chrysalis at *d*.

The caterpillars form cylindrical silken tubes in which they feed and transform to chrysalids, and it is this habit of web spinning that renders the insect so injurious where it once obtains a foothold. The flour becomes felted together and lumpy, and the machinery becomes clogged and necessitates frequent and prolonged stoppage, resulting in a short time in the loss of thousands of dollars in large establishments. Upon attaining full growth the caterpillar usually leaves its original silken domicile and forms a new web, which becomes a cocoon, in which to undergo its transformations to pupa and to imago.

Although the larva prefers flour or meal, it will attack grain when the former are not available, and it flourishes also on bran, prepared cereal foods, including buckwheat grits, and crackers. It has recently been discovered that this moth is inquilinous in the nests of a wild bumblebee in California, and Mr. D. W. Coquillett reports that it also occurs in the hives of the honey bee.

M. Danysz has demonstrated that the insect is able to complete its life cycle in from two to two and a half months, but from experiments conducted during the year at Washington it is estimated that under the most favorable conditions, i. e., in the warmest weather, the life cycle consumes about five weeks. In its outdoor life there are probably not more than two or three broods in the year, but in well-heated mills or other buildings six or more generations may be produced.

This insect is rapidly becoming distributed throughout the civilized world, but as yet its range is limited. As might be inferred from its alarming destructiveness in Great Britain and Canada, this moth is peculiarly qualified for an indoor existence in much colder climates than most other grain insects.

When a mill is found to be infested, the entire building should be fumigated, and in case a whole district becomes overrun, the greatest care must be observed not to spread the infestation. Uninfested mills should be tightly closed at night and every bushel of grain, every bag or sack, brought into the mill, subjected to a quarantine process, being disinfected either by heat or bisulphide of carbon.

THE INDIAN-MEAL MOTH.

(*Plodia interpunctella* Huebn.)

A phycitid moth allied to the preceding and known as the Indian-meal moth is widely distributed and injurious to a great variety of edibles. It is nearly omnivorous, feeding on grain and farinaceous products of all kinds, dried fruits, seeds and nuts of various sorts, condiments, roots, and herbs. It is even injurious to dried insects in cabinets, and is said to feed on sugar, jellies, and yeast cakes, and is occasionally troublesome in bee hives. In short, this moth is an all-around nuisance in granaries and stores and in the household. It is the caterpillars of this species which are so often found in dried apples, currants, raisins, English walnuts, etc.

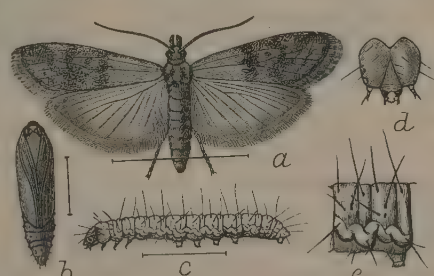

FIG. 47.—*Plodia interpunctella*: *a*, moth; *b*, chrysalis; *c*, caterpillar—somewhat enlarged; *d*, head, and *e*, first abdominal segment of caterpillar—more enlarged (original).

The adult moth, as will be seen by reference to the accompanying illustration (fig. 47, *a*), resembles in general contour *Ephestia kuehniella*. It measures across the expanded wings between a half and three-fourths of an inch. The inner third of the fore wings is dirty whitish gray, and the outer two-thirds is reddish brown, with a dull coppery luster. The caterpillar is shown at *c*, *e*, and *d*, and the chrysalis at *b*.

Aside from its omnivorousness, the habits of the Indian-meal moth are essentially the same as those of the preceding species. The larvæ

surround themselves with cylindrical silken webs, in which they feed and undergo their transformations.

Experiments conducted during the past year show that the insect is capable of passing through all its several stages, from egg to adult, in thirty-three days, which furnishes a possibility of six, seven, or even more generations in the heated atmosphere in which it habitually lives.

THE MEAL SNOUT-MOTH.

(*Pyralis farinalis* Linn.)

A moth belonging to the family Pyralidæ often occurs in barns and other buildings wherever farinaceous products are housed. In Europe, where it is known as the "meal moth," it has long been known as a domestic nuisance, and in this country it is evidently on the increase.

The meal snout-moth is slightly larger than any of the species previously mentioned, having a wing expanse of nearly an inch. The ground color is light brown, with reddish reflections; the thorax and the dark patches at its sides and near the tips of the fore wings are darker brown. The wavy, transverse lines of the wings are whitish, and form the pattern indicated in the illustration (fig. 48, *a*). The caterpillar and chrysalis are figured, natural size, at *b* and *c*, respectively.

FIG. 48.—*Pyralis farinalis*: *a*, adult moth; *b*, larva; *c*, chrysalis—natural size; *d*, head of larva; *e*, anal segment of same; *f*, tip of pupa—enlarged (original).

The habits of the meal snout-moth are similar to those of the two preceding species. The caterpillar constructs long tubes of silk and particles of the meal or other food in which it lives, and when present in mills hides away, particularly in the pupating season, in machinery and other places where it would be objectionable. European authorities state that the insect is biennial in development, but this is a subject requiring further investigation. It lives on cereals of all kinds and in all conditions, either in the kernel or in the form of flour, meal, or bran, and even, it is said, in the straw. It also attacks other seeds, and dried plants in herbaria, and injures hay after the manner of the related clover-hay worm (*Pyralis costalis*). Very recently it has been reported injurious to potatoes.

THE WOLF MOTH.

(*Tinea granella* Linn.)

Still another moth, known as the wolf moth or little grain moth, does considerable injury to stored cereals in Europe; but as it is not particularly destructive in America, requires only passing mention. This species is of about the size of the Angoumois moth, creamy white in color, thickly mottled with brown. Like the latter, it is known to oviposit in grain in the field. It infests cereals of all sorts, and a single

caterpillar is capable of great damage, as it has a habit of passing from one grain to another, spinning them together with its webs as it goes until twenty or thirty grains are spoiled. When full grown the caterpillars crawl all about the infested mass, leaving their webs everywhere, thus injuring even more than they consume.

THE SAW-TOOTHED GRAIN BEETLE.

(*Silvanus surinamensis* Linn.)

This little beetle is widely distributed over the entire globe, and is of common occurrence in granaries, in groceries, in dwelling houses, and in barns, and, in fact, almost everywhere where edibles are stored. It is nearly omnivorous, infesting grain and seeds of all sorts, flour, meal, bran, screenings, breadstuffs, and other comestibles. It has been reported as specially injurious in different years in Michigan, Mississippi, Oregon, Delaware, and other States, and has been the subject of a series of experiments at the Oregon and Delaware experiment stations.

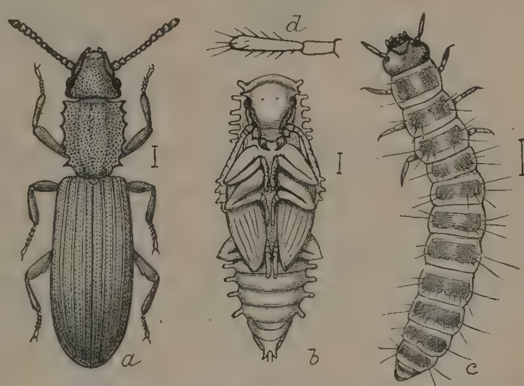

FIG. 49.—*Silvanus surinamensis*: *a*, adult beetle; *b*, pupa; *c*, larva—all enlarged; *d*, antenna of larva—still more enlarged (original).

The insect is a clavicorn beetle of the family Cucujidæ. It is very small, only about one-tenth of an inch long, slender, much flattened, and of a dark chocolate-brown color. The antennæ are clavate, and the thorax has two shallow longitudinal grooves on the upper surface and bears six saw-like teeth on each side, as shown at figure 49, *a*.

The larva, as will be noticed by reference to the illustration (*c*), has six legs. It is exceedingly active, and does not pass its life wholly within a single seed, but runs about nibbling here and there. After attaining its growth the larva attaches itself to some convenient surface and constructs a covering by joining together small grains or fragments of infested material by means of a silken substance which it secretes, and within this case the pupa (*b*) and afterwards the adult states are assumed. From data acquired by experiment during the year it is estimated that there are six or seven generations of this insect annually in the latitude of the District of Columbia. During the summer months the life cycle requires but twenty-four days; in spring, from six to ten weeks. At Washington, it has been learned, the species winters over, in the adult state, even in a well-warmed indoor atmosphere.

THE FLOUR BEETLES.

During the past year two little tenebrionid beetles, popularly known as "flour weevils," viz, *Tribolium confusum* and *T. ferrugineum*, have occasioned considerable alarm among millers, flour and feed dealers, grocers, and dealers in patent foods. The two species resemble each other so closely that it is only with the aid of a magnifying glass that a difference can be detected, and their habits are also very similar.

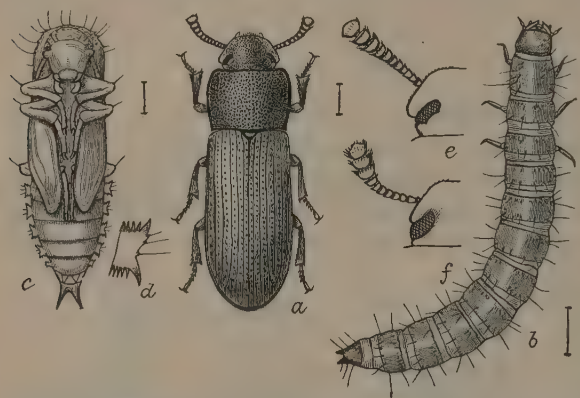

FIG. 50.—*Tribolium confusum*: *a*, adult beetle; *b*, larva; *c*, pupa—all enlarged; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of *T. ferrugineum*—all greatly enlarged (original).

For many years these insects have been known in Europe as enemies of meal, flour, grain, and other stored products, and even as pests in the museums. Although they live in grain, their chief damage, probably, is to flour and to patented articles of diet containing farinaceous matter. The eggs are deposited in the flour, and these and the young larvæ, being minute and pale in color, are not noticed; but after the flour has been barreled or sealed up in boxes and left unopened for any length of time the adult beetles make their appearance, and in due course the flour is ruined. A part of the trouble caused to purchaser, dealer, and manufacturer is due to the fact that the insects are highly offensive, a few specimens being sufficient to impart a disagreeable and persistent odor to the infested substance.

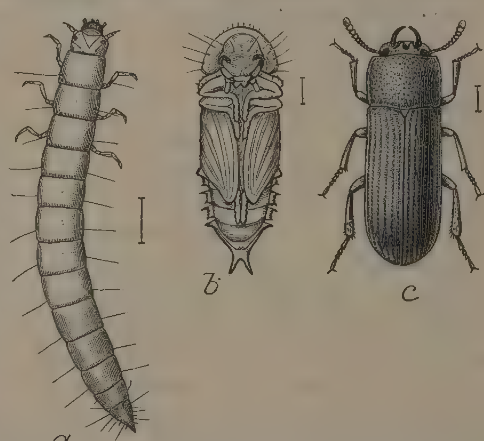

FIG. 51.—*Echocerus maxillosus*: *a*, larva; *b*, pupa; *c*, adult male—all enlarged (original).

In addition to the two species of Tribolium, there is another similar beetle that attacks grain, viz, the slender-horned flour beetle (*Echocerus maxillosus*), which will be mentioned hereafter.

The confused flour beetle (*Tribolium confusum* Duv.) is a minute, reddish-brown beetle, elongate and depressed, of the appearance repre-

sented in the illustration (fig. 50, *a*), and the size indicated by the hair line. It is separable from *ferrugineum* chiefly by the structure of the antenna, which is gradually clavate, as may be seen at *e*. The head, it will be noticed, also differs from that of *ferrugineum*, shown at *f*. The general characters of the larva are illustrated at *b*, and the pupa at *c* and *d*.

From experiment during the year it was learned that this species, in an exceptionally high temperature, is capable of undergoing its entire round of transformations in thirty-six days, but in spring and autumn weather it requires a much longer time. In well-heated buildings, at this rate, there are at least four, and possibly five, broods during the year.

The injuries reported of this species, as noted down in the records of the division, far outnumber those due to any other farinivorous insect. During the year the species has been received in a patented food purchased at a local grocery, in wheat from New Mexico, in flour from Massachusetts, in oatmeal, in flour and meal from Indiana, and in corn, peanuts, and seeds. We have also notes upon its feeding upon snuff, orris root, baking powder, rice chaff, graham flour, red pepper, and upon dried insects. During August this insect was reported as very destructive in western Massachusetts to flour received from different sources in the West, having been the cause of extensive damage and much annoyance to the interested parties. A Western miller having dealings in the East stated that he had also been troubled with this insect at Portland, Me., Boston, and New York.

The rust-red flour beetle (*Tribolium ferrugineum* Duv.) resembles in general appearance the preceding species, but may be distinguished by the antenna having a distinct terminal three-jointed club (see fig. 50, *f*). The larva and pupa also strongly resemble those of *confusum*. Within the year it was found to have damaged two lots of imported cotton seed at the Department. At the Columbian Exposition it was present in injurious numbers in most of the cereal exhibits from the tropics; also in cakes, yams, nuts, and seeds of many kinds. The species is widely distributed, and is common in the United States, particularly throughout the South.

The slender-horned flour beetle (*Echocerus maxillosus* Fab.) has habits similar to those of the two preceding species, and is of common occurrence in the Southern States, where it lives on grain in the field as well as in the granary, and even under the bark of trees. This species is probably a native of tropical America, and although not positively known to have established itself north of southern Ohio, is gradually extending northward. It has recently been found in Washington breeding in shelled corn. It lives also in flour and meal.

This beetle resembles Tribolium, but is lighter in color and a little smaller, measuring a trifle over an eighth of an inch in length. On

the head, between the eyes, are two pointed tubercles, and the mandibles in the male are armed with a pair of slender, incurved horns. The insect in its several stages is illustrated at figure 51.

THE SQUARE-NECKED GRAIN BEETLE.

(*Cathartus gemellatus* Duv.)[1]

An insect of some importance in the South is the square-necked or red grain beetle. It is undoubtedly identical with a European species, and in the United States occurs as far north as New York.

The beetle is of about the same length as the saw-toothed species, to which it is nearly related and somewhat resembles; but the head and thorax are nearly as broad as the abdomen; the thorax is nearly square, not serrated on the sides, and the color is shining reddish-brown.

This species has received special mention by Townend Glover (Pat. Off. Rept., 1854, p. 66), and is treated in bulletins on grain insects recently issued by the Mississippi and Maryland stations. It breeds in corn in the field as well as in cotton bolls, and continues breeding in harvested grain. The eggs are laid at the base of the kernels, into which the larvæ bore, and afterwards complete their transformations. Glover states that corn injured by this species has little chance of germinating, as the germ is nearly always first destroyed, and that this fact may, in some degree, account for the numerous failures of seed corn to grow, of which Southern planters so often complain.

THE CADELLE.

(*Tenebroides mauritanicus* Linn.)

An account of the insect enemies of stored grain would not be complete without reference to *Tenebroides mauritanicus*, the larva of which is called by the French "cadelle." It has long been known to feed upon stored grain in Europe, where it is said to be extremely injurious. In this country it has never been reported as especially destructive, although of common occurence everywhere in grain infested with other insects. It is not, however, so injurious as many of the preceding species, as its predaceous habits partially offset its destructiveness. The question has been raised as to whether or not this species fed upon stored grain, the claim being made that it was strictly predaceous. Experiments conducted by the writer prove that the larva not only feeds upon grain, but is capable of very serious injury to seed corn from the habit it has of devouring the embryo or germ, going from kernel to kernel and destroying many more seeds than it consumes. It is also predaceous, both in the larval and adult stages, and even destroys its own kind.

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[1]Some confusion exists in regard to the synonymy of this species. It is the *Silvanus quadricollis* Lec., and has been incorrectly referred to *S. cassiæ* Reiche.

The adult cadelle is an elongate, oblong, depressed beetle of a dark brown color and about a third of an inch in length. The larva is fleshy and very slender, and measures when full grown neary three-fourths of an inch. In color it is whitish, with a dark brown head. The three thoracic segments are also marked with dark brown, and the tail terminates in two dark, horny points.

REMEDIES.

The measures to be observed in the control of insects in stored grain are both preventive and remedial, but before taking up the consideration of the various remedies that may be used with more or less benefit, and the precautionary measures that may always be observed with profit, it should be borne in mind that we have in the bisulphide of carbon a nearly perfect remedy for all insects that affect stored produce.

A few words must be said in answer to a question that is often asked, viz, What varieties of grain are the least susceptible to "weevil" attack? There is no weevil-proof grain. Unhusked rice, oats, and buckwheat are practically exempt, but unhulled barley is attacked with avidity. Husked, shelled, or hulled grain is still more liable to attack. The soft varieties of wheat are greatly preferred, and the small, hard-grained varieties are little troubled with insects. Corn, when shelled, is more susceptible to the attack of most species than when on the cob, but appears to be preferred by the Angoumois moth in the latter condition. The hard, flinty varieties and such as have a closely fitting husk are not so liable to insect attack, and corn has been kept for years nearly exempt from infestation by this moth by being housed in the husk or shuck.

Exclusion of the insects from the granary.—The measures that may be observed to prevent the infestation of the grain are manifold. As has already been said in treating of the Angoumois moth, it is impossible entirely to prevent this insect from entering the grain in the field. The same is true to a limited extent of a few of the other species in the extreme South; still all but a very small percentage of damage from this source may be prevented—first, by harvesting as soon as the grain is ripe; second, by thrashing as soon afterwards as possible.

In the process of thrashing many of the infested kernels will be blown out with the chaff and dust, and the insects killed by the agitation which the grain receives. The moths and many weevils are destroyed in the thrashing, but the eggs, larvæ, and pupæ, many of them, survive this treatment, and further measures are required for their destruction. In France, where the Angoumois moth is so injurious, a number of machines have been devised for the treatment of infested grain. Into these the grain is poured, and either revolved while exposed to heat or subjected to a violent agitation which kills the contained insects. A new machine for the destruction of grain insects in mills is figured and described in Insect Life (Vol. VII, p. 263).

Better, however, than these devices, simpler and less expensive, is the establishment of a quarantine bin, as nearly air-tight as possible, in which the newly thrashed as well as the infested or suspected grain may be placed, before being disposed of for more permanent storage, and fumigated with bisulphide of carbon according to the directions which will be given in the closing chapter.

Prevention of infestation to fresh grain.—The next precaution to be observed is that the grain after thrashing be not exposed to infestation from being placed in bins that contain infested grain, or even housed under the same roof with such grain.

The granary should be built at some distance from other buildings and the rooms in which the grain is to be stored should be constructed so as to be as near vermin-proof as possible. The doors should fit tightly, the windows should be covered with frames of wire gauze to prevent the entrance of insects from without and the escape of those within to the fields, and the floors should be oiled, painted, or whitewashed.

Before storing fresh grain in old bins that have been badly infested they should be thoroughly cleaned, all the old grain removed, and the floors, walls, and ceilings brushed and scrubbed.

The natives of India store their wheat in air-tight pits to preserve it from the rice weevil, and condemn ventilation. In the colder countries of Europe and in North America, on the contrary, ventilation is practiced, and with decided benefit.

The practice of storing grain in large bulk is also to be commended, as the surface layers only are exposed to infestation. This practice is particularly valuable against the moths, which penetrate only a few inches beneath the surface. Frequent handling of the grain by shoveling, stirring, or transferring from one receptacle to another is also destructive to the moths, as they are unable to extricate themselves from a mass of grain, and perish in the attempt. The rice and granary weevils, however, penetrate more deeply, and, although bulking is of value against them, it is not advisable to stir the grain, as it merely distributes them more thoroughly through the mass.

It is advisable to remove the surface layers before grinding.

Impractical, useless, or unnecessary remedies are often recommended, and a few words concerning these may not be amiss, if only to point out the defects of such as are worthy of notice.

Repellants, counter-odorants, and lure traps.—On the hypothesis that insects are extremely sensitive to odors, the use of many aromatic substances has been recommended for deterring insects from entering the grain, in driving them from it, and as baits for luring them away. Among such substances are garlic, "jimson" weed, coriander, fennel, aniseed, hemp, larkspur, ivy, box, rue, lavender, tansy, hops, wormwood, elder and pecan flowers, China berries and twigs, neem leaves, tobacco leaves and stems, and oil of turpentine. Admitting that any

of these are of substantial value, and this is doubtful, they must be used in tight receptacles and in large quantity to be effective.

Among substances that have been employed with more or less benefit are salt, powdered sulphur, naphthalene, camphor, pyrethrum, and air-slaked lime. These, when sprinkled about in tight bins, have been productive of beneficial results in keeping out insects. In the preservation of samples of all sorts of products subject to insect attack, naphthalene, either in crystal or in the form of "camphor tar" or "moth balls," is very extensively employed, and when used in air-tight receptacles is an almost perfect preservative. It can not be recommended for grain that is to be used for food on account of its powerful and permanent odor.

Heat and cold, and other remedies.—Until the adoption of the bisulphide of carbon as a fumigant, heat was relied upon as the best agent in the destruction of these insects. It has been ascertained by experiment that a temperature of 140° F., continued for nine hours, literally cooks the larva and pupa of the Angoumois moth, and that a temperature of from 120° to 130° F., continued for four or five hours, is fatal. It has also been experimentally proven that wheat can be subjected to a temperature of 150° without destroying its germinating power.

Kiln-drying, at a still lower degree of heat, has been found effective.

A low temperature is equally destructive, and in colder climates these insects may be successfully dealt with by stirring or turning the infested grain, or by filling the building with steam and then throwing open the windows of the building at night and exposing the insects to frost.

Tobacco, sulphur, chlorine, benzine, and naphtha have been recommended and tried as fumigants against grain insects, but none of them produce entirely satisfactory results, their vapor being insufficient for the destruction of the adolescent stages of our most injurious species, which breed wholly within the kernel, while all of these agents possess an offensive odor which is more or less persistent in the grain after treatment. The vapor of benzine and naphtha is also inflammable. Sulphur, properly applied, may be used with benefit in buildings where for any reason the use of bisulphide of carbon is not advisable, and steam and sulphur combined are very destructive to insect life.

THE BISULPHIDE OF CARBON TREATMENT.

The simplest, most effective and inexpensive remedy for all stored-grain insects is the bisulphide of carbon. This is a colorless liquid with a strong, disagreeable odor. It vaporizes abundantly at ordinary temperatures, is highly inflammable, and is a powerful poison.

A number of methods for the application of the bisulphide of carbon have been suggested and tested, but the most effective manner of applying the reagent in moderately tight bins consists in simply pouring the liquid into shallow dishes or pans or on bits of cotton waste and distributing about on the surface of the grain. The liquid rapidly volatilizes, and, being heavier than air, descends and permeates the mass of grain, killing all insects as well as rats or mice which it may contain.

The bisulphide is usually applied in tight bins at the rate of a pound to a pound and a half to the ton of grain, and in more open bins a larger quantity is used. Mr. H. E. Weed, who has experimented with this insecticide in Mississippi, however, claims that 1 pound to 100 bushels of grain is amply sufficient to destroy all insects, even in open cribs. Bins may be made nearly air-tight by a covering of cloths or blankets. Oilcloth and painted canvas are excellent for this purpose.

Mills and other buildings, when found to be infested throughout, may be thoroughly fumigated and rid of insects by a liberal use of the same chemical. A good time for fumigating an entire building is during daylight on a Saturday afternoon or early Sunday morning, closing the doors and windows as tightly as possible and observing the precaution of stationing a watchman without to prevent anyone from entering the building. It is best to begin in the lowest story and work up, in order to escape the settling gas. The building should then be thoroughly aired early Monday morning. The bisulphide is usually evaporated in vessels, one-fourth or one-half of a pound in each.

Certain precautions should always be observed. The vapor of bisulphide is injurious to all animal life, but there is no danger to a human being in inhaling a small quantity. It is also explosive, but with proper care that no fire of any kind, as, for example, a lighted cigar, be brought into the vicinity, no trouble will be experienced.

Infested grain is generally subjected to the bisulphide treatment for twenty-four hours, but may be exposed much longer without harming it for milling purposes. If not exposed for more than thirty-six hours its germinating power will be in no wise impaired. In badly infested buildings it is customary to repeat this treatment about every six weeks in warm weather.

Bisulphide of carbon is for sale at drug stores at from 20 to 30 cents a pound, but at wholesale in 50-pound cans it may be obtained at the rate of 10 or 15 cents a pound.

A grade known as "fuma bisulphide," for sale at 10 cents a pound, is said by experienced entomologists and others who have experimented with it to be much more effective than the ordinary grades on the market.

The cost of treatment is thus only 10 cents a hundred bushels.

THE DAIRY HERD: ITS FORMATION AND MANAGEMENT.

By Henry E. Alvord, M. S., C. E.

The pursuit of dairy farming depends for its success upon certain fundamental conditions. First, the owner of the business himself, or otherwise the agent or manager who has the immediate control and personal direction of the work, must have a natural fondness for animals, prompting to generous and kind treatment, as well as good judgment in selection, breeding, and care. It is not sufficient that he should be a horseman, or fond of cattle in general; for best results he should have a special liking for the dairy cow, over and above all other animals. Second, the cattle must be good of their kind and of a variety suited to the work. They must be truly dairy cattle; but of this more presently. Third, the farm should be specially adapted to the branch of husbandry in view. A good dairy farm is pretty certain to be good for general farming, but many good farms in general are not suited to dairying. The dairy farm should be carefully selected, all the requirements of the business being well considered. Yet many disadvantages so far as the farm is concerned may be successfully overcome by the skillful dairyman, and dairying in some forms is profitably conducted without any farm, so that this condition, important as it is, can not be regarded as essential. Fourth, it is well to study the character of the accessible markets and the means of communication; location and the line of dairying to be followed may be largely controlled by the markets. In some cases the markets form an essential condition, but modern facilities for transportation make the location of the dairy farm with relation to its markets comparatively unimportant. The first and second above remain as the essential factors—the owner and the cow. Assuming that the dairyman is all he should be, it is proposed to consider in the following pages the dairyman's main stock in trade, upon which depends his success—the dairy herd, its formation and management.

Like almost all other occupations at the present day, dairying has become divided into several distinct and special lines. These differ mainly as to the form of product and the manner of disposing of it. Milk or cream may be produced for delivery to consumers, and this delivery may be direct or indirect. The same products may be delivered to a factory for manufacture into butter or cheese, or the milk product of the herd may be worked up at home and there converted into butter or cheese. The prudent dairyman should first consider

which line of business he will pursue. In so doing he must have regard for all his circumstances—the location, markets, farm, buildings, water and ice supply, the labor at his command—and his own preference, and prospects for profit. Upon his decision as to the particular kind of dairying to be followed should depend the character and composition of his herd of cattle.

DAIRY CATTLE FOR THE DAIRY.

In making up a herd for this business, no matter what the special line, only such animals as are truly dairy cattle can be considered. Everyone now admits that there is a distinct type or class of cattle specially adapted to dairy purposes. This class includes various kinds, families, and breeds, but all have the marked characteristics which distinguish the milk producer from the beef producer. To succeed in his business the dairyman should select his herd, or its foundation, solely from this class—from dairy cattle. There are some people who seem to still really believe in the possibility for profit of an animal combining qualities for producing milk and butter and beef all in one hide. These good people are still searching for "the general-purpose cow." When found, this animal will be like the "Jack at all trades—good at none." There may be good carpenters who are ready to argue the economy of a single saw for all purposes, but very few will be found to practice this preaching; every workman of experience who knows his own interests has his crosscut and his ripper, and never attempts to make either do the work of the other. The writer has been too long a dairyman and has become too strongly impressed with this phase of the subject to spend time in further argument. In all work, with rare exceptions, the best results come with the best tools or instruments. The dairyman seeking best results will buy, breed, and feed only such cattle as are of marked dairy type and belonging to families of established dairy excellence.

SPECIAL ADAPTATION.

Within the general class of dairy cattle one can find great variety; one is thus enabled to select breeds or families well adapted to the special needs in view. Some dairy cattle are noted for the quantity of milk they produce; others for the high quality or richness of their milk, which means butter producers. Some combine quantity and quality in a specially economical way, under some circumstances. There are cows of active habits, which forage well on a wide range of scanty pasture, and will profitably work up the coarser kinds of food in winter. There are others which have proved their capacity for making good returns when more closely confined and subjected to high feeding. Some cows give a great flow of milk for a comparatively short season, and others are noted for an even, steady yield of milk the year through. The dairyman can easily find cattle, therefore, adapted to his particular

wants. As a rule, the different dairy characteristics named pertain to different breeds, so that every dairyman is likely to find some one breed of dairy cattle better suited to his wants than any other.

This is not the place to revive the never-ended "battle of the breeds." No matter how strong one's convictions, discretion must be exercised. Pronounced opinions and direct advice as to the several recognized dairy breeds are here unnecessary. Evidence abounds on every side, and every dairyman that is, or is to be, can satisfy himself as to the cattle he should adopt, if he will but make a proper study of the subject. He need not go far in this country to find the best kind or breed of cows for milk supply, the best for butter making, or the best for the cream trade. There is no special cheese-making cow; the best butter cow is also the best for cheese; this fact has been demonstrated beyond dispute.

FORMATION OF THE DAIRY HERD.

There are two very different ways of forming a dairy herd and of maintaining its size and quality. It may be done by buying or by breeding, and these two methods may be combined. The purchasing plan is practiced to a considerable extent by those who produce milk for town and city supply. In a few cases it has been known to be successful where the work of the herd was to make butter. Applied in its extreme form, cows are bought when mature and at their prime, judged almost exclusively by their milk yield, are highly fed so as to keep steadily gaining in flesh, and are sold, usually to the butcher, as soon as they cease to be profitable as milkers. The bull may be of any kind so long as he gets the cows in calf, and the calves are valued only as causing "fresh" cows, and are dispensed with as soon as possible. The first modification of this system is to keep extra good cows for several seasons and the next to raise heifers from some of the best milkers to replenish the herd. This way of making up a herd and keeping good its numbers requires abundant capital and rare judgment in buying and in selling. It can not be recommended to one lacking experience, and even the shrewdest buyer runs great risk of bringing disease into his herd.

The other extreme is to begin with a few well-selected animals as a foundation, and gradually build up the herd to the size desired by judicious breeding and natural increase. This method takes time, and time which may be money, but it is by far the safer and more satisfactory in its results, and it must be recognized as a higher grade of dairy farming.

A desirable combination, in starting, is to buy the number of cows desired, and good animals of the sort determined in advance. If one's means will permit, include a few superior cows, and a first-class bull at any rate. Let the cows selected be such as have had two calves, and perhaps three, so that they may be judged by their own development

and yet be young enough to improve and be in full profit for some years. With a herd thus formed, begin at once the work of improvement by breeding and selection. Sell promptly any cow which proves unsatisfactory and replace her by the best increase of the herd, or purchase occasionally an animal which will raise the average quality.

PURE-BRED DAIRY CATTLE AND GRADES.

A dairyman can hardly be advised to buy at once a full stock of pure-bred cattle of any breed, if his sole object and dependence for profit is to be the dairy product of the herd. Such a venture will necessitate large investment, and should include the breeding of registered animals, for sale at remunerative prices, as a part of the business. Well-bred and well-selected grade cows, of the line of blood desired, seem to be the most profitable animals for the practical dairyman, or at least the best to begin with. If enterprising and progressive, the owner will hardly be content with grades only. He may begin with only his bull pure bred; presently he will want a registered cow to match, then one or two more. Thus he will be steadily and properly working toward a purely bred herd. If the breed chosen is the right one for the object sought, it will soon be found that the more of this blood the herd contains the better. Starting with half-bred cows (the offspring of pure-bred bulls and dams of mixed or uncertain blood), the next grade, three-fourths pure, will prove better dairy stock, if the bull is what he should be and the increase has been culled. Another step higher is better still, better for the dairy, and so the grading goes up and improvement goes on until the blood of the herd is practically pure. The best dairy results may thus be reached, but the herd has a taint. It lacks pedigree. Its increase, however excellent in dairy performance, must pass and sell as grades. The owner feels this, and is pretty sure to gradually replace his well-bred cows, almost pure bred, with fully pedigreed and registered animals. This end is reached sooner and easier by starting with one or two registered females, and, of course, a registered bull. Moderate investment and the lessened risk of loss in the hands of one unaccustomed to handling registered stock, and finding a market for the surplus, doubtless favor grades for the dairy herd. The argument and the probabilities of success, based upon the fixed principles of breeding, are on the side of pure-bred, registered stock. In the hands of experienced men the latter prove the more profitable in actual practice.

In these days any dairyman who wants registered animals of any of the approved breeds can get them if he will but make the effort. The beginner in registered dairy stock can not be too strongly urged to buy and breed on the basis of individual and family merit and dairy record, and not upon pedigree alone. Pedigree is of value and should be well studied; it is the best guaranty that the calves to come will make good cows. But the pedigree should be supported by uniform excel-

lence in the family and by evidence of merit in the particular animals bought. Although the investment is greater, there is greater certainty of good results if mature cows are bought which show what can be expected of them, if they have not already made a record, than if calves or undeveloped heifers are selected. It is also economy, having chosen the right breed, to purchase good representatives of that breed, rather than be content with only average or even ordinary animals. Successful dairying has proved that the greater profit comes from the best cows, whatever their kind. This is as true of pure-bred or registered stock as of common cows. It is better to pay $300 for three excellent cows than to pay the same for four good cows or five which are only fair. A really superior dairy cow of a superior family, with pedigree which gives assurance of calves equal to the dam, if not better, is always worth a large price. Such an animal adds much to the average value of any dairy herd. In buying registered cattle deal only with men of reputation as breeders and of strict integrity; "the best part of a pedigree is the name of the breeder."

THE BULL AND HIS TREATMENT.

With any dairyman who depends upon breeding and rearing calves for the maintenance of his herd and its improvement, the choice of a bull is a matter of prime importance. The bull is constantly referred to as "the head" of the herd, and that trite saying, "The bull is half the herd," should never be forgotten. Every calf added to the herd takes half its blood from the bull. Often this is the more important half. The bull is always the main dependence for raising the average quality of the herd, and should be chosen with this object in view. This is especially true if the cows are grades and "grading up" is in progress. The grade dam may be selected and largely relied upon to give size, form, constitution, and capacity of production to her heifer calf; its dairy quality, the inbred power to increase the richness of milk, is derived from the pure-bred sire. One cow may prove a poor dam, or fail to breed, and still give a profit in milk. Such a loss is comparatively trivial and the fault easily corrected. But if the bull fails, or proves a poor sire, the entire increase of a year may be lost. In getting a bull, get the best. At least approach that standard as nearly as possible. Make a study of the animal's pedigree and the dairy history of his ancestors, and especially of the females among his nearest of kin. Then see that the good qualities of his progenitors appear to be reproduced in the animal in question. A common error among dairymen is to use immature bulls and to dispose of good ones before their merit as sires has been fairly proven. Bull calves are cheap, and young bulls are considered much easier to handle. But it is good advice to the buyer to purchase a bull of some age, whose progeny prove his value as a breeder, rather than a calf of exceptional pedigree; and to the owner, having a sire of proved excellence, to keep him and use him

for years, or as long as he shows himself potent and prepotent. (Of course the question of too close inbreeding is not forgotten and must not be overlooked by the breeder.) The writer is a thorough believer in the use of mature bulls of known value as sires.

The chief objection made to bulls of some age is that they are likely to be vicious and dangerous. Everyone recognizes the difference in temperament between the fleshy, beefy bull and the one of pronounced dairy character; but experience and observation have taught that the bulls of marked dairy type are much alike in disposition, regardless of breed. In all the breeds (as among men) some bulls will be found of naturally bad temper, but it is believed that the great majority of bulls, of all the dairy breeds, can be safely kept until too old for service and handled without serious trouble, if only properly reared and judiciously managed.

In rearing a bull, accustom it to being handled from calfhood, but without fondling or encouraging frolic. Give it kind, quiet, firm, and unvarying treatment, and keep it always under subjection, that it may never know its strength and power. Insert the nose ring before it is a year old, keep this renewed so as to be always strong, and always lead and handle the animal with staff in the hands of a discreet and trusty man. The bull should never run loose in yard or pasture, but should be provided with abundant and regular exercise, always under restraint and full control. The "walk around" arrangement, like the sweep horse power, affords a fair degree of voluntary exercise, but is hardly sufficient. The best plan seems to be to provide a suitable tread power with a governor attached, place the bull in this daily, and let him walk a fixed time or known distance. The main object should be regular and sufficient exercise for the bull. Incidentally, he may be made to run a fodder cutter or a cream separator and perform valuable service. As age and strength increase, let the staff be supplemented by strap, chain, or rope attached to a second ring. To this may well be added some hitching or leading chain with a strong strap around horns or neck. Let there be always a double hitching device, so that the bull may never by accident find himself loose when he should be tied. If restiveness and temper are shown, add to the exercise, in duration or quantity, without violence; a bull physically tired may be depended upon to be quiet and easily managed.

It is much better to keep the bull as much as possible in the presence or in full sight of the herd than stabled by himself in a lonely place. Let him be in the same room with the cows during the stabling season, and at milking times the rest of the year.

INDIVIDUALITY AND CULLING THE HERD BY ITS RECORD.

As soon as the herd is established and in working order, the study of every individual animal should begin. To guide rational treatment and insure greatest profit, the owner must become familiar with the

characteristics of every cow. Peculiarities of temperament, susceptibility to surroundings and varied conditions, and especially the dairy capacity of the animal, should be matters of observation, deliberation, and record, not merely of conjecture and memory. The record of the herd is a matter of utmost importance. The system of record should conform to the circumstances of the case and extent of the business. (It is desirable to reduce the labor of bookkeeping to a minimum, and yet accuracy and sufficiency of record must be secured. Fortunately, inexpensive forms can now be found for sale, which are based upon long experience, and in variety to suit different wants.) The record should include a concise history and description of every member of the herd, with a summary of the dairy performance. The latter requires a daily record of the milk yield of every cow, with notes explaining irregularities or occurrences of interest. If the quality of the milk is a matter of any importance, as it is in most cases, and ought to be, however the milk is disposed of, a fat test should be made of the milk of every cow, for several consecutive milkings, as often as practicable. Some form of the Babcock tester is the simplest and now within the reach of every dairyman. According to the size of the apparatus, a certain number of milk samples can be tested at one time, and thus the record of a large herd can be completed in a few days. It is well to make this test and record of the quality of every cow's milk at least once a month. The most satisfactory practical record is the average percentage of fat found in the milk of several successive milkings, samples from which may be mixed and this "composite sample" tested, thus obtaining the average; the method is easily learned and practiced. This record of quality, taken periodically, joined with a summary of the daily quantity of milk, gives a full dairy record of the cow, upon which her value can be readily computed. To give the owner a more complete knowledge of his operations, there should also be a record, of at least approximate accuracy, of the food of every cow, with monthly summaries of quantities or value, so that the economy of production may be shown.

Such records are far more easily made than the description may indicate, and are well worth all they cost. They form the only accurate and safe basis for judging of the individual merits of the different animals. The improvement of every herd, which should be the constant aim of its owner, depends upon periodical culling and getting rid of unworthy members. No one can afford to do this upon guesswork alone. One well-authenticated example of the value of keeping such record follows: A dairyman of wide reputation, president of a State association for years, concluded to adopt the daily milk record, rather because of those who advocated it than of any conviction of needing it himself. His herd was of his own breeding; he had handled every cow from its birth, and he and his sons did the milking. Before beginning the record he made note of the joint opinion of himself and

sons as to the half dozen best cows in the herd and an estimate of their season's milk yield. When the year's record was completed it was found that in order of actual merit the cows actually stood thus: First, his fifth; second, a cow not on his merit list; third, his fourth; fourth, his first; fifth, his sixth; sixth, like the second; and his second and third still lower on the list. These facts were verified by subsequent records. Still more remarkable, this experienced owner proved literally "by the book" that about one-fourth of his cows were being kept at an actual loss, while others barely paid their way.

Good judges believe that in the entire country one-third of the cows kept for their milk do not pay for their cost of keeping, and nearly a third more fail to yield annual profit. As a matter of ordinary business prudence and a condition essential to best results, every dairyman should study the individuality of his cows, keep a sufficient record of quantity and quality of milk product, know approximately the cost of production, and systematically weed out his herd. After proper consideration and practical tests as to possibilities, set a standard for a satisfactory cow and maintain this standard by promptly disposing of the animals which fail to attain it, unless reasonable excuse appears, with the prospect of better conduct in future, and gradually but persistently raise the standard.

ACCOMMODATIONS FOR THE HERD.

The large and lofty barn, in which to keep the cattle and the crops, the manure and farm implements, all within four rectangular walls and under one roof, can no longer be regarded as perfection. No matter how well arranged and how thorough the ventilation, the danger of loss and damage is too great. It is well to house all the forage, and a large storage building may be necessary. Economy of labor requires the forage to be easily placed before the cattle. The best modern practice calls for a separate or slightly attached building for the cows, with no manure cellar under them and no large quantity of forage above them, and preferably none at all. The best provision for such manure as can not be at once applied to the land is an open shed or covered yard. The cow house should be on the ground level, rather than in a basement, and be light, dry, and roomy. A room open to the roof, which is fairly high, is better than a low, level ceiling above the cows. The former may involve a little more work to keep free from dust and cobwebs, but it affords the air space needed for health and comfort. The latter necessitates special arrangement for ventilation, and these, constructed on the best plans, often fail to work in practice. Sanitary authorities advise 600 cubic feet of space for every animal, but the best cow house the writer has seen allows double this quantity, and it appears none too much. Where the climate will permit, there is no better plan than to let cows stand upon the ground, the clay or earth being packed

hard and raised somewhat above the level around the building; shallow gutters behind the cows, and a feeding floor in front of them. More durable floors, and quite expensive, are made of grouting and cement, or of brick on edge; but such are damp and cold, causing rheumatism and other ailments, unless covered with a false floor of wood or provided with an unusual abundance of bedding. Box stalls are undoubtedly the ideal for cows as well as for horses; in a box 8 to 10 feet square a cow may be left untied, and if supplied with enough bedding she will keep clean and well, although the stall is not cleaned out for months at a time. But such boxes for a large herd require too much room. Every cow should have her own stall, however, wide enough for comfort of cow and milker, and well protected from the neighbors on either side; 3½ feet width is little enough and 4 feet is better.

From the great variety of cattle ties one should be selected which combines, in greatest measure, freedom of movement, comfort, and cleanliness. There are serious objections to all stanchions; if some form of this device is insisted upon, let it be one which is so hung as to move a few inches in any direction. A desirable substitute for a stanchion is a wide strap or light chain around the neck, with a ring at the throat (this part to be always worn by the cow), and a snap, with a few links of chain, attached to an iron ring which moves freely upon a 3 or 4 inch post, fastened upright at the middle of the side of the feed box next to the cow. An excellent patented device consists of a flattened bow of metal or wood, shaped like a widely spread letter U, the ends hinged at the front corners of the feed box, the bow resting on the back edge of the box, and the neck strap fastened to this bow at its middle; this gives much freedom of movement and causes the animal to move backward a little when it lies down and forward when it rises. An open, level feeding floor in front of the cows seems to be better than any form of boxes; if boxes are used, they should be as large as possible and yet have every part within reach of the cow as tied, and they should be so constructed as to be easily cleaned. A manure gutter behind the animals aids in cleanliness, but while it should have good width, 16 to 24 inches, it should not be too deep; if enough to hold the droppings of a night, that is sufficient. "Self-cleaning" stalls and gutters have not proved successful. The length of stall from fastening to gutter should suit the size of the cow; it is bad practice to have them so long as to induce filthy udders and legs, and also to have them so short that cows stand habitually with hind feet in the gutter. Arrangements should be convenient for removing the manure and for supplying absorbents for the urine, and a limited quantity of bedding. Liberal use of land plaster about the gutters and the floors over which the cattle pass is very desirable as a disinfectant and conserver of ammonia. Lime should be used with equal freedom, as whitewash on the walls of the cow house, but not on its floors.

The stable should be provided with windows to admit light and air abundantly, and arranged to let sunlight as nearly as possible into every portion of the apartment where the cows stand during some hour of every clear day. Yet the windows should be shaded when desired, and they should be fixed to open partly without subjecting the cows to direct drafts of air.

The extremes in providing water for the cows are to be avoided. A long walk to get water, in all weather, is certainly objectionable. And all the devices for keeping water constantly before every cow, or supplying it at the stalls, at will, are open to serious objections. Some medium course is advised, and the best plan seems to be to provide one or more tanks in the yard and one or more in the stable, at each of which but one cow should drink at a time. These should fill quickly after use and freely overflow, that every cow may find the surface fresh and clear. The evidence is conclusive that water for milking cows should not be too cold, and that it is profitable to bring water in severely cold weather to a temperature of about 50° F., if it can be cheaply done. Warming to blood heat has not been found advantageous.

Attached to the cow house should be an exercise yard for the daily use of cows during the stabling season. Roomy open sheds should form a part of this inclosure, and the whole may well be roofed over, if arranged for the free circulation of air and for admitting sunshine to a large share of it, while excluding wind and storm.

HEALTH OF THE HERD.

There is no point of greater importance in selecting animals for the foundation of a herd, or in making purchases of additions, than to get perfectly healthy stock. Animals chosen should be critically examined by a veterinarian if convenient, and should afford evidence of being strong in constitution and of healthful vigor. Besides the robust character of the individuals, the breeding stock from which they are descended, and the herd, stables, and farm from which they come, should be closely examined, on the score of health. Breeding and rearing the animals needed to replenish and increase the herd, and refusing to allow strange animals on the farm, are the best safeguards against the introduction of disease. If purchases must be made, let the new stock be strictly quarantined for at least one month before mingling with the herd. On every farm of any size a well-secluded building for a stock quarantine and hospital, suitably arranged and equipped, is a most useful adjunct. This is not needed for calving cows, or for cases of lameness or ordinary accident, but for cases of acute sickness, retention of afterbirth, abortion, or any symptoms of contagious disease, it is essential. Of course, the building itself, its care, and the attendance upon its occupants must be subjected to regulations suited to any hospital or quarantine.

There are many of the ordinary accidents and ailments to which domestic animals are subject which can be managed by an intelligent owner, or under his direction, without professional assistance. "Every man his own cattle doctor" is a very delusive title; one may well follow this suggestion within reasonable limits, but there is always a point, hard to define, at which professional aid should be promptly summoned. So long as an owner is certain as to the difficulty, and has knowledge and experience as to treatment or remedy, he may depend upon home resources. But in a case of obscurity, uncertainty, or complications, the owner of a good cow disregards his own interests and his moral obligations if he fails to summon a veterinarian, as much as if he neglected to secure proper medical service for a sick child. And the veterinarian should be selected with the same care one exercises in choosing a family physician.

Close confinement, with impure air and lack of exercise, is as prejudicial to the health of milch cows as to that of human beings. Some recently promulgated theories of dark, warm stables and no exercise for profitable milk production are without rational basis and certain to lead to disastrous results sooner or later. Exposure to storms and cold is equally injurious to the health and profit of cows. A judicious mean is the provision for moderate exercise in the open air and sunshine, and the application of the same common-sense care for the comfort of cows which one would approve for members of his own household.

Every member of the herd, young or old, should pass under the critical eye of the owner or his trusty assistant daily, and preferably twice a day. The least symptoms of disorder, like dullness, loss of appetite, rough coat, and irregularity of milk, manure, or urine, should be noted and promptly receive the attention which it deserves. Experience is needed on the part of the care taker to detect and correct the beginnings of trouble, and thus maintain the general health of the herd.

FALL-FRESH COWS MOST PROFITABLE.

Much has been written upon the best season for cows to drop their calves. Opinions still differ, and by far the greater number of milch cows are allowed to follow the most natural course, and either by indifference or intention they "come in" in the spring. The producer of milk for sale, if he has an even trade, may want to have about an equal number of fresh cows every month in the year. If the bull is kept up and service controlled, this can be regulated as a rule, although unpleasant irregularities in breeding will sometimes occur and stubbornly resist correction. But if the prime object is to produce the greatest quantity of milk of the best quality and at the greatest profit from any given number of cows within a year, the evidence is overwhelming that the cows should be managed so as to calve in the autumn months. For like reasons, September is the best month, in most parts

of the country, for a heifer to drop her first calf in order to best develop as a cow, and this almost regardless of the age of the animal at first calving. Calves born in the fall are easier reared and make better cows than those born in the spring or summer. It seems needless to rehearse the stock arguments on this subject, based upon the long experience of successful dairymen, but a brief recapitulation may be useful. The cow or heifer calving in the fall needs the most healthy and nutritious pasturage just following the strain and while coming into full flow. Just at the time when some falling off is likely to occur, the animal is brought to the stable and receives good care; the winter feeding and the returns from it may be depended upon to exceed the midsummer results for any like period. At the stage of milking and of gestation, when another dropping off in the milk yield may be looked for, the fresh pasturage induces a fresh flow, lengthens the milking season, and increases the year's total product. December and January are good months in which to control and supervise the service of the bull. Midsummer and the dogdays are a good time for the cow to be dry and preparing to calve again, and a most unprofitable and annoying time to make milk or handle it. The greatest product and the richest comes at the season when milk and butter are always comparatively high in price. In actual practice four fall-fresh cows have been found to equal five which calved in the spring, in twelve months' product, and at about four-fifths the cost.

DRYING OFF COWS AND CALVING TIME.

It is not unusual to find a cow which shows no inclination to dry off at any time after dropping her first or second calf. Such an animal shows an excellent dairy trait—persistence in the milking habit—but it is doubtful if continuous milking is profitable. Better results are believed to be obtained from cows which are inclined to take an annual rest, if not too long. A month is long enough; three weeks will do in most cases, and six weeks should be the longest time encouraged or allowed for a cow to be dry before calving. An accurate record of service by the bull is essential to preparations for drying off cows at the right time. A table should be kept of the dates when cows of the herd are successively due to calve, with notes as to the milking habit of every one. When the time comes for drying off a cow the grain food should be gradually withdrawn. This may of itself cause milk to cease forming. If not, omit one milking a day, then milk but once in two days, and thus extend the drying period over two weeks. The udder must be watched, and if any hardening or unnatural heat is shown regular milking must be resumed. If a cow continues to secrete milk it must be drawn. No cow should be forced to "go dry" against manifestly natural resistance to so doing. On the other hand, if an unpleasantly pungent or "smoky" taste appears in a cow's milk she may as well be dried at once, regardless of dates, as her milk will not be good until she is fresh again.

The dry cow may be kept on pasture alone, not too luxuriant, or on a low stable diet, mainly of coarse forage, until about two weeks before calving. Yet the ration, while comparatively "wide," should be nutritious, and it should include a share of succulent food—roots or silage. Then a slow but steady increase of feeding may proceed, of a nourishing, cool, and laxative kind, so as to become narrower in ratio. Wheat bran is a good material to use at this time, but new-process linseed meal is better. Experience has led the writer to endeavor to have his cows calve on an upgrade, as it were, while daily gaining in strength and vigor, on a judiciously prepared, nourishing diet, but without high feeding or plethora. A week before calving remove the cow to a roomy, comfortable, quiet box stall, preferably within hearing of the herd, if not in sight. Be sure the bowels are quite loose and moving freely for two days before calving. Watch for the event, but do not disturb the cow or interfere unless something goes wrong or assistance is manifestly necessary.

ABORTION AND MILK FEVER.

In herds the best regulated and cared for there will occasionally occur a physical accident or some sudden fright which causes a cow to prematurely drop her calf. The herds should be constantly watched for symptoms of abortion, which will generally be recognized by the experienced herdsman. Should such symptoms appear the suspect should be immediately removed to hospital until the case is over or the signs disappear. In case abortion occurs in stable, yard, or pasture, despite precautions, and wholly without warning, as is sometimes the case, take the animal to hospital at once and use every exertion to thoroughly clean and disinfect the place where the accident occurred. The aborted cow should be carefully nursed and the genital organs freely dressed with antiseptic solutions. The animal should not return to the herd until fully cured, clean, and free from all vaginal discharges. Be on guard for a second case following the first in a few days or within three weeks; if a month elapses recurrence is not to be expected. But "sympathetic" (?) cases are likely to soon follow the first, and the disease may appear in a neighborhood or on a single farm as an epidemic, run its course, and disappear. Extended and expensive investigations have failed to give any satisfactory explanation of this dread disease or prescribe means for preventing it. It seems probable that it belongs to the class of germ diseases which requires further research.

Milk fever, "dropping," or parturient apoplexy is another scourge of the dairy, twin to abortion. It is an affection which comes without warning, attacks the deepest and richest milkers, is sudden in attack, rapid in progress, and generally fatal. The symptoms are a chill, twitching of the head muscles, failure to eat, chew the cud, or pass manure, distended udder without milk, insensibility of the hind quar-

ters when pinched or pricked; later the cow becomes unsteady on her hind legs, and presently drops. Good cows should be carefully watched for forty-eight hours after calving, and if such warnings appear a veterinarian can not be called too soon. Preventive measures form the best assurance of the owner against losses from this cause. The cow should have abundant exercise up to the week before calving, and then quiet and good care, with daily grooming and active rubbing. Keep the bowels active with proper food, or purgatives if necessary. Insure comfort, guard against cold, and endeavor to maintain active circulation on the surface of the body. A strong dose of physic and brisk grooming may be used immediately after calving in the case of cows believed to be predisposed to milk fever.

CARE OF CALVES AND YOUNG STOCK.

Among dairy cattle the best practice is to remove the calf from the cow within twenty-four hours after its birth and at once teach it to drink. This separation may be delayed until the dam's milk assumes the normal condition, but as a rule the earlier the calf is taken in hand and its feeding regulated, the better for the calf. The younger it is, the easier it learns to drink. It is also better for the dairy cow to be regularly milked by hand than to suckle a calf. The milk of good cows is often too rich for their calves, and the latter are apt to take too much if left to help themselves. The calf should have the milk of its dam or some other fresh cow, and receive it while warm, and at least three times a day (preferably four) for a week or month. During this time, if the milk is rich, it should be diluted with warm water one-fifth to one-third its own bulk, according to the richness, or the milk may be kept a few hours, the best of the cream removed, and then warmed and fed. To make a good calf, three feedings a day should be kept up for a month or six weeks, and the milk should be fed warm for a longer period, especially if the weather is cold. But after ten days or so milk set twelve hours and lightly skimmed will do, and after ten days more the skimming may be gradually made closer, until at the end of a month or soon after a skim-milk diet is reached. No rule can be given for quantity in feeding calves; they differ so much in size and food requirements. Judgment must be used, the feeding effects observed, and the calf given enough to thrive and be active, but not too much. More calves suffer from overfeeding than from scant diet. Keep the calf a little hungry and eager for more rather than fill it to dullness. The endeavor should be to prevent the beginning of indigestion, which leads to scouring and perhaps fatal diarrhea. Nothing causes indigestion sooner than overfeeding or irregularity in the quantity, time, and temperature of the milk, especially while the calf is young; and absolute cleanliness about the feeding vessels is essential, with frequent scalding. If it can with certainty be kept equally clean, some feeding

device which compels the calf to suck its milk instead of swallowing rapidly is preferable to the open pail; but, all considered, the latter is usually the best utensil. If gritting the teeth or other symptoms of indigestion appear, a little limewater in the milk or a little baking soda will usually prove a correction. Keep the calf dry and clean, fairly warm, but in pure air, and allow it to exercise. If its box is small, turn it daily into a covered yard or small paddock. Young calves like company, but if kept together are likely to learn bad sucking habits. Every calf had better have its own box until a month or two old, and then be tied up out of reach of neighbors; but several may exercise together if not turned out until an hour after taking milk.

The calf here referred to is not supposed to be for veal, but to be raised for a dairy cow. The foregoing treatment should be accompanied by early lessons inducing it to eat sweet hay and a little grain. The sooner it learns to eat hay or other rough forage and the more it eats, the better; but keep up milk feeding as long as possible, if only once a day. Grain should be used sparingly, oats and bran preferred, perhaps a little linseed, and always to judiciously supplement the other food. Do not turn it on to grass too soon. If a spring calf, carry it over to the second summer without pasturage. A fall calf will be in good shape to get its living from pasture its first summer.

Fall calves are generally better cared for, thrive better, and make better cows than those dropped in the spring; another reason for having cows calve in the autumn. The writer feels certain of getting better results, in the end, from raising four calves dropped at the season advised than from five born in the spring, and is inclined to make the comparison stronger.

From the time milk ceases to be the main food of the calf until the heifer drops her first calf (at which time she becomes a cow, if ever, regardless of age) the feeding of the animal should be with a view to nourishment and growth, without accumulation of flesh. When pasturage is good, after the calf is six months old, there can be no better food; if grass is short or dry and growth slackens, supplement with clover hay, wheat bran, or oats. At other times let the food be mainly the coarser and more bulky kinds of forage; the digestive apparatus needs to be developed and become accustomed to working up large quantities of food. A big belly may result, but no matter. If accompanied with a well-sprung rib, a strong back and loin, depth of flank, and other marks of constitutional vigor, a big belly is to be desired, indicating capacity as a feeder and user of feeds. Give long forage, fodder, or "roughness" the preference with young stock, and use grain sparingly as needed to balance the ration and promote growth and thrift. A fall calf, well bred and healthfully grown, should "come in" when just about two years old, and ought to make a good cow.

ATTENDANCE AND MILKING.

A herd of good dairy cows deserves to have good care, and this can only be insured by having the right kind of attendants. If the owner is unable to either attend the cows himself or give the matter personal supervision twice a day or more, it is to his interest and profit to be certain that his employees are trustworthy and fit to be cow keepers. Everyone should be quiet, even-tempered, gentle, and regular and cleanly in his habits. A cow abominates an unclean man. Tobacco in all its forms is obnoxious to every department of dairying. All the work about the herd should be done with the utmost system and regularity—stable cleaning, grooming, exercise, watering, feeding, milking; a fixed time for everything and everything at its time—"on the dot." Nothing has been produced which begins to compare with the human hand as a milking machine. Cleanliness and regularity are the first requisites in good milking. Next, quiet and gentleness should be accompanied by quickness. Two milkers, one rapid and the other slow (the cow being accustomed to both), will get about the same quantity of milk in any given number of days, but the former will get the more fat. The quicker the milking, the richer the milk, if the work is done well and completely; the difference may not be great, but it is measurable in butter or money. Again, two men milking like quantities in like time, from the same cows or animals giving milk usually just alike, will get different results as to richness, and if they change places the richer milk is secured by the same man. The milk fat or butter fat comes from the cow, but it is the expert milker that gets the most of it. There seems to be an undefined and yet conclusively proved relation between some milkers and the cows they handle which produces this result. It is certain that change of milkers, manner or time of milking, irregularity, or any disturbance at milking time may be expected to cause loss of butter fat in the milk. In short, it pays, and pays well, to have milking done in the very best way, by the very best milkers that can be found. A superior milker should be appreciated and retained as persistently as a superior cow; the former is the more difficult to replace.

A very good practice, although uncommon, is to take every cow to a particular place to be milked, apart from where she usually stands; this to be a clean and airy place, like an open shed. The milking shed or room being kept scrupulously clean, with free movement of pure air, there is an almost certain exemption from what are usually called "animal odors" in milk, but which really are stable odors or odors from the milker. It may be stated as a fact, and should always be remembered, that milk as it comes from the healthy cow is perfectly pure. It has by nature no unpleasant taste or smell (except an occasional result of peculiar food), and all those odors and flavors which are often so

objectionable get into the milk after it is drawn from the udder of the cow. They come from the uncleaned body of the cow herself, or from her surroundings, the air of the stable, the milk vessel, or the clothing or person of the milker. These troubles are all avoidable; they are not to be charged to the cow, but to the man, her keeper.

With the exception of some extraordinarily large milkers, or for short periods when the yield is largest, there is no gain in milking cows more than twice a day. Within limits, it is true that, if properly done, the oftener a cow is milked the richer will be the milk; but the difference is very slight, and seldom, if ever, enough to pay for the extra labor. In one of the most noted and fully authenticated cases of immense milk production by one cow (a ton or more of milk a month for a year), the cow was milked every six hours for 365 days, every time by the same man, and always within two minutes of the right hour. This remarkable record was without doubt largely due to the milker, who was the feeder of the cow as well; indeed, the year's performance by the man was as noteworthy as that of the cow.

THE PASTURE SEASON AND SOILING.

As soon as the spring grass gets high enough for the cows to get a bite, let them have it. At first the time daily on pasture should be very short, for the good of both pasture and cow. The latter should be gradually changed from stable feeding to pasturage, especially if the feeding has been of dry material or mostly so. And the stable feeding should continue unchanged, undiminished, until the cow herself indicates that she is getting enough grass to replace a part of the stable ration. Then, as the pasturage improves, indoor feeding may be lessened and finally discontinued. If a pasture furnishes an abundance and variety of grasses, there can be no better food found for the milch cow. The nutritive ratio for mixed pasturage is about 1 to 5, which can not be improved for succulent food. But the best of pasture grasses contain from 65 to 75 per cent of water, sometimes more, and the cow must procure a large quantity of this material, 100 pounds or so in the course of a day, to secure the food material required. Shade and water should be carefully looked after in connection with pasturage, as well as the grass. In very large pastures there should be watering places in different parts of the inclosure, as well as shade, that the cows may not be compelled to travel far to find either.

Until flies become bad, cows had better stay in pasture by day and in stable by night, or be left out all the time. But in the worst fly time, and perhaps when the sun's heat is greatest, it is good practice to stable the herd during the day in an airy but shaded cow house, and turn it on pasture at night. If the pasture has not abundant shade and water this course should certainly be followed. Heat and flies reduce both quality and quantity of milk product. The trouble from

flies can be largely remedied by spraying the cows with a very weak mixture of water and some one of the approved sheep-dip preparations. Such a spraying will last a week or ten days, unless there are hard rains meanwhile. The entire interior of the cow house should be sprayed with a solution of this kind, and strong enough for an insecticide, weekly throughout the summer.

There is ample evidence that, although milk yield may be increased by feeding grain to cows at pasture, the gain no more than pays for the extra food, and seldom does that. There may be in some cases a small margin for profit in improving the pastures by less grazing and richer manure. But if pasturage is short, even temporarily deficient, the cows should be fed enough of grain, hay, silage, or green crops to supply the deficiency.

The dairyman who has most of his cows dry during drought, fly time, and "dog days" appreciates the advantages of "bringing in" his cows in the fall.

Soiling.—The advantages of soiling over pasturage are so great, especially where dairying on high-priced land, that every dairyman should carefully study the question of adopting this system. Much depends upon the supply, character, and cost of labor at one's command. It may be profitable to practice partial soiling where it will not be to do more. Careful trials have shown that by feeding cows wholly on green forage crops in the stable from two to five times as much milk can be produced from an acre as from pasturing the same land. Of course, farms often contain many acres of pasture land that can not be tilled, but for tillable land the profit in soiling is great. Many more cows can be kept on a given area and the productive capacity of the land can be rapidly increased. The saving of manure and its application to best advantage is one of the great gains in soiling.

For this system of feeding stock a variety of green crops is necessary, grown so as to come to best feeding condition in well-arranged succession throughout the growing season. There must be no breaks; the supply must be certain and sufficient. It is well to aim to grow about twice as much of every crop as one expects to use; any surplus can be saved by drying or putting in a silo. Crops well adapted to soiling in most parts of the country are these: Red clover and timothy, sown separately in July and August; crimson clover and barley, sown in August and September; and wheat and rye, sown in September and October—all these for use in (an open) winter and early spring. Oats, spring barley, and pease sown early in the spring; vetches, also corn and soja beans, planted or sown in May; cowpeas, corn, millets, and Hungarian grass, sown in June—these for cutting in the summer and fall. The first and second crops from the regular mowing lands of grass and clover will fill in the gaps.

A good deal of skillful management is needed to bring on the crops at the right time in proper succession and in sufficient quantity. At least

110 pounds of green forage should be provided daily, on the average, for every 1,000 pounds' weight of cow; the quantity will vary much with the character of crop. By the soiling system, well managed, 1 acre may feed two cows for five or six months, and 3 acres for five cows is a conservative estimate.

One of the points of gain by soiling is saving the food expended by the animal in its exertion to procure its food at pasture. But moderate exercise should accompany soiling, and a small pasture lot or large paddock should be provided convenient to the cow house for use of the herd, especially at night.

THE STABLING SEASON.

Up to a certain point fall pasturage is as good as in any other part of the year. But after one or two hard frosts it is well to offer the cows some nice hay when they come in at night, and if they eat it with relish, one may be pretty certain the season has arrived to gradually change the herd from pasture to stable for the winter. The cows should not be left out at night after it becomes chilly, or be exposed to cold autumn storms. They may be allowed in the field a few hours on all pleasant days until snow flies, but without expecting them to get much besides water and exercise. Before keeping them steadily at the stable and yards the feeding should be, by gradual steps, completely changed to the full stable diet.

Meanwhile, or on leisure days earlier in the year, the cow house should be prepared for its occupancy by the herd throughout the stabling season. Boxes, stalls, and feeding troughs or floor should be thoroughly cleaned and disinfected, so that no animal can discover or be subjected to any unpleasant traces of another and previous occupant of the place. Then assign every cow her particular place for the winter, and gently insist upon every one being always in the right place. The bedding, absorbents, and disinfectants should be provided in abundance and in ample time for all to be quite dry. Use no damp material under a cow, no rotten straw, and no moist earth or sawdust. In order of efficiency, the best absorbents are peat, spent tanbark, sawdust, wheat straw, forest leaves, and dry earth. If earth alone is used, from 30 to 40 pounds per cow will be needed daily—a big shovelful. If straw alone, provide 9 or 10 pounds a day, and less if cut short. A good combination is 5 or 6 pounds of straw and 10 or 12 of earth or sawdust. An excess of bedding or litter is undesirable. If the floor on which the cow lies is dry and not cold, very little litter is needed for true bedding. Its chief use is as an absorbent, and if more than necessary for this object is used, the manure becomes too dry and bulky, and is lessened in value per load. Land plaster is a very satisfactory disinfectant or deodorizer about a cow house. If one takes good care of the manure and intends to add chemical fertilizer, the latter may be

used in the stable, in some forms, instead of plaster. A refuse of the "double phosphate" works is an article called phospho-plaster. This can often be got at about the same price as common plaster, and as it contains about 1 per cent of phosphoric acid, it is a good addition to the stable manure, while also an efficient disinfectant. Kainit, about the lowest grade of German potash salt, is a good substitute for plaster in the stable. It costs half as much again, sometimes twice as much, but less of it may be used, and the potash it contains (11 to 13 per cent) is a very desirable addition to the manure in several ways. From 1 to 2 pounds of kainit or plaster per day to each cow can be profitably used, scattered in the litter and along the gutters of the cow house throughout the stabling season.

It is a mistake to be satisfied with watering the herd but once a day. If they can be induced to drink twice or three times a day, it should be done. Cows need much water. It has been found that the average milch cow requires about 81 pounds of water a day while in milk (nearly 10 gallons), and about 53 pounds while dry. Of this, the cow in milk takes rather more than two-thirds (say, 7 gallons) as drink, and the rest in her food, while the dry cow takes rather less than two-thirds as drink, and a little more than one-third in the food.

FEEDING THE HERD.

The first advice is not to feed the herd as a herd. Cows differ in their tastes and in their requirements in the way of food just as human beings do, although perhaps not to the same extent. To feed all the cows in a herd alike, day after day and month after month, as is so often done, is an absurd and wasteful practice. Some are sure not to get enough for greatest profit, and others are likely to get more than they will use to advantage. This as to quantity only; but differences in kind of feed may be equally desirable. In a thorough study and comprehension of the question of feeding lies the greatest opportunity for the exercise of real economy in the management of the dairy herd.

Scientific feeding means simply rational feeding, a common-sense application of a good understanding of the objects of feeding, the character of food materials, their proper relations, combinations and effects, and the needs and characteristics of the animals in hand.

The principles of scientific feeding, the composition and digestibility of feeding stuffs, the food requirements of animals for various purposes, and the calculation of rations have been explained in Farmers' Bulletin, No. 22, issued by the Department of Agriculture. The composition of a large variety of feeding stuffs grown and employed in this country is also given in an appendix to this volume. To these, therefore, the student of the great feeding problem is referred, as that is much too big a subject to discuss in detail here.

In practice it is more common and convenient to measure grain food than to weigh it when mixing rations for cows. Yet one may want to

keep weights in mind at the same time. For this purpose the following little table is handy and approximately correct:

Grain foods—relations of weights and measures.

Food stuff.	Half bushel weighs—	One quart weighs—	
	Pounds.	*Lbs.*	*Oz.*
Wheat, whole	30	1	14
Cracked corn	28	1	12
Gluten meal	26	1	8
Cotton-seed meal	25½	1	9
Corn meal	23½	1	7
Corn and cob meal	22	1	6
Wheat middlings	18	1	2
Oats, whole	16	1	0
Ground oats	12	0	12
Wheat bran	10	0	10

Some of the articles named are quite variable in weight, however, wheat bran especially, and weighing is always the safer way. No cow house is properly equipped without its scales for weighing feed stuffs and milk, and its book, paper, or slate, with pencil for making notes and records in connection with the feeding, the milk product, and all facts of interest and desirable for preservation.

GENERAL NOTES.

There are various other questions which arise in the consideration of the problem of feeding the dairy herd which have not been touched upon, and but a part of which can even be mentioned here. On the practical side, one should ascertain the kind and quantity of feeding stuffs which have been produced and are available on the farm, the best way of preparing these for the cattle, and the matter of markets in its relation to getting those articles which it seems desirable to buy in order to supplement the home supplies and balance the rations. On the scientific side, there are a good many additional points which deserve careful attention—the relations of breed and feed in the economy of dairy practice; the effects of different foods upon the production of milk and butter, in quantity and in quality, having the item of flavor prominent; effects of food upon the economy of churning or "the churnability" of the cream; and the comparatively new subject of bacteriology in its bearings on dairying, the health and cleanliness of the cow house, and the preservation of products.

The whole subject of animal nutrition is under investigation and discussion, and by watching the publications of American experiment stations and the reviews of foreign work new suggestions of practical application will be found appearing at intervals.

The manure from a well-fed dairy herd is a matter of great consequence, and its proper management requires judgment. The better the feeding, the better the manure. While all manure is worth good care, the better the manure the more important it is to handle it well to prevent heavy losses. The best single piece of advice as to handling stable manure is to get it from the stable to the land where wanted, and there spread it with the least labor and the least delay possible. Yet this general plan must be modified at times, and according to circumstances.

A few publications may be here named which the manager of a dairy herd will find of interest and useful for reference:

Report on Diseases of Cattle, Bureau of Animal Industry, United States Department of Agriculture, 1892; and especially "Cattle feeding," a chapter in the same report, by Professor Henry.

Handbook of Experiment Station Work, 1893. United States Department of Agriculture.

Bovine Tuberculosis. Bulletin No. 7, 1894. Bureau of Animal Industry, United States Department of Agriculture.

Leguminous Plants for Green Manuring and Feeding. Farmers' Bulletin, No. 16, 1893. United States Department of Agriculture.

Farm Manures. Farmers' Bulletin, No. 21, 1894. United States Department of Agriculture.

Feeding Farm Animals. Farmers' Bulletin, No. 22, 1894. United States Department of Agriculture.

SOME PRACTICAL SUGGESTIONS FOR THE SUPPRESSION AND PREVENTION OF BOVINE TUBERCULOSIS.

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Tuberculosis among domesticated animals, more particularly among cattle, has during the past few years received a large share of attention, mainly because of its possible direct influence on human health. With this idea in the foreground, the bearing of this malady on agricultural interests has been more or less obscured. As a result we have a great mass of publications on the hygienic aspect of tuberculosis and but very little on the prevention of this disease among cattle. Many of the more valuable contributions to our knowledge have been made in order to show more definitely what degree of tuberculosis makes an animal unfit for food. This point of view, while bringing out now and then valuable facts, does not pay sufficient attention to the animal during life. What to do to reduce the high percentage of infection among living animals has been practically ignored in all but a few recent publications. It became evident to the writer some years ago that this was, after all, the most important aspect of the serious problem of bovine tuberculosis. If the disease can be restricted and repressed among cattle during life, the hygienic problem will take care of itself.

To attack tuberculosis as it exists at present is undoubtedly a most difficult problem, and the conditions which tend to repress or to augment its further dissemination are very complex. No single measure, however sweeping, is likely to be successful. A number of details will have to receive careful attention, and in the end the success will depend largely upon the intelligent watchfulness constantly exercised in various directions by the stock owner. The wide dissemination and the localized intensity of this disease, especially in herds devoted to breeding purposes, will require, above all, concerted action in attempts for its repression.

Though a strictly bacterial disease and introduced into the body only by the tubercle bacillus, which is always derived from some preexisting case of disease, tuberculosis differs, nevertheless, from most animal diseases in very important particulars. Its unknown beginnings in the body and its insidious march after it has once gained a foothold are responsible for the existence of a large number of tuberculous animals in all stages of the disease. In the earlier stages, while the disease is

still restricted to a single focus, the animal is to all outward appearances in perfect health. It is only after the infection has invaded several cavities of the body or produced mechanical obstructions that it becomes manifest. The prolonged latency of the first stage of the disease, with little or no discharge of tubercle bacilli, raises the question, What should be done with such cases? A comparison with some other infectious diseases makes the predicament all the clearer.

When an animal becomes infected with anthrax or with Texas fever, the specific microorganisms begin to multiply at once within the body. Within twenty-four hours in the case of anthrax, and a few days to a week in Texas fever, the symptoms are fully developed, and death or recovery speedily follows. There can be no question here concerning degree of disease or utility of the animal during the earlier stages. The infected and the noninfected are divided by sharp unmistakable barriers. In tuberculosis, on the other hand, the infected animal is practically well during the earlier stages of the disease, and the disease may become stationary, possibly healed. This peculiarity of tuberculosis modifies to a certain extent the usual measures employed to repress an infectious disease. In certain diseases the necessity for the destruction of all infected animals becomes imperative, because the disease must be kept restricted and suppressed as soon as possible. The present wide dissemination of this disease and its prevalence among other domesticated animals, such as dogs, cats, horses, goats, and above all, its prevalence in man, makes the complete extinction of this malady an unrealizable problem, or at most one whose ultimate success can not be positively predicted.

It is largely due to these peculiarities that tuberculosis has received so little attention until recent years. Its unrecognizable beginnings and slow, insidious march in the body made it appear on the surface as a disease not of infectious origin, but as one in which inheritance played an important part. After the discovery of the true cause in the form of a bacterium (*Bacillus tuberculosis*) by Koch the conception that infection played the most important rôle has gradually gained a firm foothold. Without in any way wishing to eliminate the factor of heredity, the writer has based the statements in the following pages entirely on the principle, now universally recognized, that without the presence of the tubercle bacillus there can be no tuberculosis. If it can be shown that the tubercle bacillus can be kept away from cattle by adopting precautionary measures the discussion concerning heredity would be useless. If, however, this should prove to be impossible, the problems of breed, heredity, and environment, or, in other words, the accessory causes, will require renewed study.

The conditions peculiar to this disease which confront the agricultural interests may be summarized under the following heads:

(1) The present wide dissemination of the disease, no territory being absolutely free from it.

(2) The large percentage of infected cattle which are in the earlier stages of the disease, or in which the lesions are insignificant, stationary, or healed.

(3) The absence of any disturbances of health for considerable periods of time after infection.

(4) The possible transmission of tubercle bacilli from animals to man, more particularly in the milk.

CHARACTER OF THE DISEASE.

Tuberculosis in cattle is at the outset a strictly local disease. Though the entire body has been, to a certain extent, influenced by the local changes, as shown by its sensitiveness to tuberculin, the tubercle bacilli themselves are restricted to that locality where the disease process shows itself to the naked eye. Where the infection has been very severe, that is to say, where there are large numbers of tuberculous cattle in a herd which are continually discharging the virus (in the manner indicated below), so that the remaining animals are being exposed to large numbers of tubercle bacilli, the disease may start in several places within the body at the same time, and its subsequent progress may be, on this account, somewhat more rapid.

In the majority of animals, however, that are killed in the early stages of tuberculosis the disease process is limited to a single spot for a time. The location of this spot will vary with the manner of infection, and possibly with other conditions not yet definitely known. In most cases the tubercle bacilli settle down at the start in some lymphatic gland and there begin to multiply. This multiplication is accompanied by an enlargement of the gland. The size attained by diseased glands varies in accordance with the number of bacilli which have settled down in them. After a certain length of time the enlargement ceases. The gland may be barely larger than before the infection, or it may have gained enormously in size. The writer has seen glands, normally as large as horse-chestnuts, become as large as a child's head.

When the enlargement has come to an end, further changes begin to take place within the gland. The new tissue produced by the presence of the tubercle bacilli begins to assume a yellowish color and to degenerate slowly into a cheesy mass. Hence, when tuberculous glands are cut open we note in those not very much enlarged yellow masses sprinkled in the gland substance, varying in size from one-sixteenth to one-fourth inch. The coalescence of these gives rise to larger cheesy masses. In those glands which have become very large the appearance of the gland when cut open is somewhat different. The cut surface, at first grayish in color, later on appears permeated with a network of yellowish lines, which network encroaches slowly upon the grayish tissue until the entire substance of the gland has become yellowish in color and tough in consistency. Gritty particles are usually embedded in it. Lastly, it may become entirely calcareous, gritty, mortar-

like,[1] or it may break down into a semifluid mass of a yellowish color, resembling soft cheese in consistency. In this state the enlarged gland is nothing more than a bag filled with this cheesy matter. Every vestige of the original gland structure has disappeared. This description of the disease process and the appearances presented by the changes to the naked eye are characteristic of tuberculosis wherever it may appear. The same cheesy breaking down occurs in the lungs, the liver, the bones, and other affected parts.

Thus far the disease may have been entirely restricted to the gland or system of glands in some one part of the body. The process may have lasted a year or longer. When the softening takes place, the disease may become stationary, or, what is perhaps more likely to happen, blood vessels in the gland may become broken down and the tubercle bacilli in the softened mass carried in the blood to other parts of the body. This is usually the time when the infected cow will begin to show outward signs of disease and when the milk may carry tubercle bacilli. Bacilli may be carried in the blood to the uterus and there they may set up tuberculosis, and, in case of present or future pregnancy, infect the unborn calf.

The outcome of the disease may be neither in cure nor in a general infection of the body. It may take a middle course. It may slowly creep from gland to gland. The lining membrane of the chest and the abdomen may become studded with peculiar masses of tubercles which crowd upon the vital organs and interfere with their movements. The animal may become emaciated and lose strength in spite of the best care and food, because of the large amount of tuberculous material lodged in the body. The sometimes enormously enlarged glands in the chest near the backbone compress the gullet so that gases can not escape from the stomach. The animal has irregular or regular attacks of bloating, or the glands in the back of the throat may become so enlarged that swallowing and breathing are interfered with. Food may pass down the windpipe and cause pneumonia. It has already been stated that the spot which is the first to be diseased depends, among other things, upon the manner of infection. Thus, if tubercle bacilli are taken in with the milk, there is likely to appear in the calf (1) disease of the glands of the throat; (2) disease of the glands in the abdomen, which are situated on the membrane that suspends the intestine (mesenteric glands), because the tubercle bacilli pass into these glands from the food in the intestines; and (3) disease of the liver and its glands, because the blood passing through the liver comes largely from the intestines.

If the tubercle bacilli are carried in a dried state into the body, they may lodge in the nasal passages and start up disease of the throat glands, or, what is more probable, they may pass into the lungs with the current of air. Here they may set up disease in the lung tissue, or they

[1] The conversion of the disease products into calcified masses may be regarded as a healing process. In rare cases the tubercles in the earliest stages become healed.

may pass on into the glands back of the lungs and attached to the windpipe and there first begin their destructive action.

When the bacilli pass from the blood of the mother into the blood of the fetus, they generally lodge in the liver, although they may settle down in other regions of the body at the same time.

Tuberculosis of the lining membrane of the chest and abdomen, to which reference has been made above, has given this affection the name of "pearly disease."

It has already been stated that the uterus and the udder may become the seat of tuberculosis whenever tubercle bacilli are brought to them in the blood from other regions of the body. It is probable that the uterus may be infected from without by the bull, and that the udder may be infected by hands carrying the bacilli. On this latter point the evidence is at present inconclusive.

The progress of tuberculosis in the body is modified by various conditions not yet fully understood. Age seems to have some influence. In very young animals the tendency toward a restriction of the disease by a calcification of the tuberculous masses seems to be greater than at more advanced periods of life. In aged cattle the progress of the disease seems likewise less rapid, but for reasons not yet understood. The influence of sex is not known. It is probable that the disease, other conditions being equal, makes slower progress in bulls than in cows.

The conditions under which the purely local disease becomes generalized by a distribution of the virus in the blood are not yet understood. The sudden breaking down of cows in good health, observed not infrequently, is probably the result of such distribution of the virus. We may at least provisionally assume that any strain upon the cow is likely to hasten the onset of generalized disease. Among these strains the giving birth to calves must be regarded as the greatest. The giving way of some diseased spot at this time favors infection of the blood of the calf at birth. Cows which do not recover after calving, and in which a discharge from the vagina persists after the proper time, not directly traceable to retained afterbirth, should be regarded with suspicion and promptly killed, for in such animals the milk is likely to be infected with tubercle bacilli. It is probable that other strains, such as exhaustive marches, chasing, etc., may lead to the same result.

This brief sketch of the disease is sufficient to make clear (1) the primarily local character of the disease and its usually slow progress within the body from place to place; (2) its predilection, at the start, for the lymphatic glands and the lungs. Putting the places most frequently the seat of the earliest disease first, we have the following order:

(1) Glands of the lungs (dorsal, mediastinal, and bronchial).

(2) The lungs themselves.

(3) The glands of the throat and intestines.

(4) The liver and its glands.

The infection of the other organs, membranes, and structures of the body, excepting perhaps the uterus and the udder in rare cases, is secondary to these. In endeavoring to comprehend the peculiar nature of this disease the reader should furthermore bear in mind that the virus, i. e., the tubercle bacilli, do not live and multiply in the blood. They are simply carried in the blood, in advanced cases, from organ to organ, and speedily fixed in the tissues, where they produce fresh crops of tubercles. In the earlier stages, when single glands only are the seat of the disease, the blood is free from infection. This accounts for the immunity of the milk in these stages. If there were any method of distinguishing these cases the danger incident to the milk supply could be easily removed. In practice, however, no such distinction can be definitely made; hence the suspicion which rests on all milk which comes from infected herds.

Tuberculosis thus differs from other infectious diseases not so much in its nature as in the degree of its activity. It is a disease long drawn out, presenting stages, covering months and years, the duration of which in other more rapid diseases is measured by days.

THE CONTAGIOUSNESS OF THE DISEASE.

This is linked to the tubercle bacillus, for without it tuberculosis can not develop. Hence our knowledge of the transmission of the disease is derived largely from what we know of the life history of the tubercle bacillus within and without the animal body. Tubercle bacilli may pass from diseased animals in the following ways:

(1) In discharges coughed up, in the case of advanced disease of the lungs. When the glands of the throat are diseased, they may, after a time, break down and discharge into the throat. Other glands about the head and neck may discharge directly outward.

(2) In discharges from bowels, in advanced stages.

(3) In discharges from vagina, in case of tuberculosis of the uterus.

(4) In milk, when the udder is tuberculous or the disease generalized.

(5) Tubercle bacilli may pass from the mother to the fetus in case of tuberculosis of the uterus or advanced generalized disease.

Tubercle bacilli may be taken up by cattle in several different ways:

(1) Fully nine-tenths of all diseased animals examined have been infected by inhaling the tubercle bacilli, dried and suspended in the air.[1]

(2) Fully one-half of all diseased animals examined have been infected by taking tubercle bacilli into the body with the food. This implies that both food and air infection are recognizable in the same animal in many cases.

[1] These estimates are of course merely approximate. Not a few animals who have lung disease reinfect themselves by swallowing the mucus coughed up, or by soiling their own food with it.

(3) Animals are infected, though rarely, during copulation. In such cases the disease starts in the uterus and its lymph glands, or in the sexual organs and corresponding lymph glands of the bull.

(4) Perhaps from 1 to 2 per cent of all calves of advanced cases are born infected. Among the 200 cases of tuberculosis, including all ages, which have been examined by the writer, there are about 2 per cent in which the disease is best explained as having been directly transmitted from the mother during or before birth.

We may define the dangers of infection somewhat more definitely by the statement that in any herd, even in those extensively infected, only a small percentage of the diseased animals, namely, those which are in an advanced stage, or such as have the disease localized from the very beginning in the udder, or the uterus, or the lungs, are actively shedding tubercle bacilli. It is these that are doing most, if not all, of the damage by scattering broadcast the virus.

Disease of the udder is particularly dangerous, because the milk at first appears normal for some weeks, and therefore would be used with impunity. Moreover, the tubercle bacilli in the diseased gland tissue are usually numerous.[1]

Similarly, in tuberculosis of the uterus the vaginal discharges may contain many tubercle bacilli. This deposited anywhere may lead to the extensive dissemination of the virus, or it may be carried by the bull to other cows. A diagnosis may be made by the examination of any existing discharge for tubercle bacilli.

The foregoing statements apply to individual herds only. To what extent does the danger extend beyond the diseased herd to others in the neighborhood? To this we may give the general answer that there is no danger unless the animals mingle on the pasture or in the stable. Tubercle bacilli are not carried in the open air, or if they are their numbers are so small that the danger of infection is practically absent.

It is also highly doubtful whether they are ever carried in sufficient numbers by third parties from place to place to become in any sense a danger. The reasons for this must be sought for in the tubercle bacillus itself. The diseased animal is the only manufacturer of tubercle bacilli, as well as the chief disseminator. Tubercle bacilli, after having left the body of the cow (and usually in small numbers), do not increase in nature, but suffer a steady decrease and final extermination in four to six months at the longest. Only after they have entered the bodies of susceptible animals do they again begin to multiply. Hence, with this disease the only danger to other herds lies in direct association, or in the transfer of a diseased animal or of milk from such an animal. The great danger exists in the immediate surroundings of the infected, and loses itself as the distance increases.

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[1] This fact, mentioned by Bang, the writer has had opportunity to confirm in case of two tuberculous udders examined recently.

PREVENTIVE MEASURES.

The suggestions to be recommended are not to be considered as taking the place of any more sweeping and radical measures which have been contemplated by some States and are actually being tried in others. We wish them to be considered simply as of educational value to the owners of cattle in their efforts to repress and stamp out the disease. The aid of the Government in this matter is a question to be discussed by itself. Without individual cooperation and sacrifice, directed by an intelligent understanding of the disease in its various aspects, any efforts on the part of the Government are likely to prove abortive, owing to the enormous interests involved.

Removal of diseased animals.—This is the essential requirement in the suppression of tuberculosis. We have already stated that only in the diseased animals the tubercle bacilli multiply. Hence, if these are removed and the stables thoroughly disinfected, so that any germs shed by them are destroyed, we are safe in concluding that the disease has been suppressed.

The disease in the early stages can be detected only with the aid of tuberculin. In the advanced stages most careful observers will probably recognize it, or at least suspect it, without the use of tuberculin. Tuberculin, therefore, has become indispensable in giving the owner an idea of the inroads the disease is making in his herd, and in distinguishing the infected from the noninfected. Tuberculin reveals to us all stages, from the earliest, most insignificant changes, when the animal is outwardly entirely well, to the gravest and most dangerous types of the disease. Tuberculin does not, as a rule, discriminate between these cases. Hence those who use it as a guide must not be disappointed when, after having killed the suspected ones, they find that many are in the earlier stages of the malady. Tuberculin, moreover, is not infallible. A small percentage of cases of disease are not revealed by it. On the other hand, a sound animal now and then gives the reaction for tuberculosis. These lapses must be borne in mind in using tuberculin. In spite of them, however, tuberculin must be considered as of great value in revealing tuberculosis not recognizable by any other means during life.

The question next arises, What shall be done with the infected animals? This question is really composed of two distinct questions whose combination is mainly the cause of the present perplexity. From the standpoint of the agriculturist alone the matter is simple enough. The infected animals might be separated at once from the noninfected. The worst cases should be killed and buried deeply or burned. Those without outward signs of disease might be fattened for the butcher and inspected at the abattoir. This is the recommendation given by Nocard, a prominent French authority, and generally followed in European countries. But at this point public health ap-

pears and demands the prompt and complete destruction of all infected animals, however mild the disease, or, if the animal be not destroyed, the rejection of the milk of all infected animals. The interest of the stock owner and of public health are thus diametrically opposed. If the demands of public health were in every sense justifiable from a strictly scientific standpoint, there could be no question as to an entire submission to its demands. But the case is not so simple, and gives room for diversity of opinion. Leaving the public-health aspect of the question aside for the moment, let us return to the farmers' side of it. After all infected animals have been segregated or killed, as the case may be, and the stables disinfected, the remaining healthy animals should be retested with tuberculin within a certain period of time, from three to six months after the first test, to make sure that no disease has been overlooked. Future repetitions must be recommended, according to our present knowledge, for some cases may have been missed by the tuberculin, or the disease germs may possibly be reintroduced by tuberculous human beings, or by tuberculous cats, dogs, and other domesticated animals.

All animals introduced into a herd must have been tested and found to be sound beforehand. This is such a self-evident proposition that it needs no comment.

In the absence of the tuberculin test, or of organized official inspection, the stock owner should carefully and promptly remove from his herd and have destroyed—

(1) All animals which show emaciation, with coughing, and any suspicious discharges from the nose.[1]

(2) Those animals with enlarged, prominent glands about the head (in front of the ears, under and behind the lower jaw), or enlarged glands in front of the shoulder, in the flank, and behind the udder, and all animals having swellings on any part of the body which discharge a yellowish matter and refuse to heal.

(3) Animals with suspected tuberculosis of uterus and udder.

Disinfection and other preventive measures.—It will probably require more or less time before the use of tuberculin will have become generally established. Hence, preventive measures of a general character must still be kept in view for some time to come. These measures partly suffer shipwreck from the fact that it is difficult without tuberculin to recognize even advanced disease during life. Still much can be done to reduce the amount of infection by following out certain general and specific suggestions which the renewed study of the disease has either originated or else placed on a more substantial basis.

[1] Now and then emaciation is due to other causes, such as the presence of foreign bodies in the chest, disease of the liver and kidneys, chronic broncho-pneumonia, etc. Animals affected with these diseases are of no permanent value, and their destruction is in the end an actual saving, since such maladies are usually incurable.

Perhaps the most important preliminary suggestion to be made is, that the owner of cattle should endeavor to familiarize himself as much as possible with the general nature of tuberculosis, its cause, the ways in which the virus may leave the body of the sick and enter that of the well, and, lastly, the ways in which it spreads within the body. He will, by the acquisition of such fundamental knowledge, lift himself above the plane where quackery and specifics abound, and understand precisely what to expect after the disease has entered his herd, and how to meet the demands of public health. He should, moreover, make himself acquainted with the peculiar appearance of tuberculous growths in the body, and open every animal that dies, so that he may know to what extent his animals are dying of this malady. Wherever possible the services of the skilled veterinarian should be made use of. Sanitary precautions should begin with the removal of diseased and suspected animals, as stated above. This is the most essential requirement, for diseased animals are the only breeding places of the specific virus.

After the removal of these, attention should be paid first of all to the stables. Here, during the long confinement of the winter months, when ventilation is all but suppressed, we may look for the source of most of the inhalation diseases so common in tuberculous cattle. Even when only a few cases of tuberculosis have been found, the stables should be disinfected by removal of all dirt and the subsequent application of disinfectants. Since tubercle bacilli are more resistant than most other disease germs, the strength of the disinfecting solution must not be less than as given. The following substances may be used:

(*a*) Corrosive sublimate (mercuric chloride), 1 ounce in about 8 gallons of water (one-tenth of 1 per cent). The water should be kept in wooden tubs or barrels and the sublimate added to it. The whole must be allowed to stand twenty-four hours, so as to give the sublimate an opportunity to become entirely dissolved. Since this solution is poisonous, it should be kept well covered and guarded. It may be applied with a broom or mop and used freely in all parts of the stable. Since it loses its virtue in proportion to the amount of dirt present, all manure and other dirt should be first removed and the stables well cleaned before applying the disinfectant. After it has been applied, the stable should be kept vacant as long as possible. Before animals are allowed to return, it is best to flush those parts which the animals may reach with their tongues, to remove any remaining poison.

(*b*) Chloride of lime, 5 ounces to a gallon of water (4 per cent). This should be applied in the same way.

(*c*) The following disinfectant is very serviceable. It is not so dangerous as mercuric chloride, but is quite corrosive, and care should be taken to protect the eyes and hands from accidental splashing:

	Gallon.
Crude carbolic acid	$\frac{1}{2}$
Crude sulphuric acid	$\frac{1}{2}$

These two substances should be mixed in tubs or glass vessels. The sulphuric acid is very slowly added to the carbolic acid. During the mixing a large amount of heat is developed. The disinfecting power of the mixture is heightened if the amount of heat is kept down by placing the tub or glass demijohn containing the carbolic acid in cold water while the sulphuric acid is being added. The resulting mixture is added to water in the ratio of 1 to 20. One gallon of mixed acids will furnish 20 gallons of a strongly disinfectant solution having a slightly milky appearance.

(*d*) Whitewash is not in itself of sufficient strength to destroy tubercle bacilli, but by imprisoning and incrusting them on the walls of stables they are made harmless by prolonged drying. Whitewashing should be preceded by thorough cleaning.

Particular attention should be paid to the sides and ceilings of stables. All dust and cobwebs should be periodically washed down. Those parts coming in contact with the heads of cattle, stanchions, halters, troughs, etc., should be frequently cleansed and disinfected, even when they have not been used by diseased cattle.

The removal of virus from the stables should, furthermore, be promoted by the regular removal of manure and by abundant ventilation. Good air has the effect of diluting infected air, and thereby reducing the chance of inhaling dried, floating tubercle bacilli, or at least of reducing the number inhaled. It likewise improves the vigor of the confined animals, and hence increases the resistance to infection.

Cattle should not be placed so that their heads are close together; each animal should have plenty of room[1] and occupy the same place in the stable at all times. These precautions will prevent the nasal, lung, or vaginal discharges from one animal striking the head or soiling the feed of another. It is true that it is impossible to prevent animals licking each other outside of the stable, but it should be remembered that prevention must begin with the removal of all cases which are suspected of discharging tubercle bacilli. Stables should, furthermore, be carefully protected from the expectorations of human beings affected with tuberculosis of the lungs.

Cattle should be housed as little as possible. The pasture has the effect of greatly reducing the chances of infection by a more or less rapid destruction of the virus, as well as by increasing the vigor of the animals through muscular exertion in fresh air. To what extent animals may pick up the virus on fields it would be difficult to estimate. That it is perfectly possible can not be gainsaid. A tuberculous animal may soil the ground over which it passes, and other animals may take up the virus with the food soon after.

It is not likely that the virus remains alive long enough on the ground to become dried and ready for inhalation. The action of sunlight, the

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[1] Each cow should have at least 600 cubic feet of air space.

alternate wetting and drying which goes on in nature, may be looked upon as destructive agents. Even if the tubercle bacilli became speedily dried, the great diluting effect of the open air would reduce to a minimum the chances of inhaling the virus.

Among the other dangers deserving attention is the infection of food and water. Drinking troughs should be so arranged that the surface water is constantly flowing away. Discharges from the nose or mouth left floating on the surface may be drawn in by healthy cattle while drinking. Each person must in such cases use his own judgment and ingenuity to prevent infection, in accordance with the quantity of water at his disposal.

To restrict the dissemination of the disease among young stock the safest plan is to bring skimmed milk and other dairy products to the boiling point before feeding them. If the cows are positively known to be healthy, this may be unnecessary, but where any doubt exists the heating should be resorted to. Such a precaution will, furthermore, reduce scouring among calves, which is probably due in a great measure to bacteria in the food.

In presenting the foregoing suggestions the writer has endeavored to keep in view two conditions: (1) That in which tuberculin is not within reach and only unusual watchfulness can be exercised in separating suspected animals from the healthy, and (2) that in which tuberculin is tried, but with the view that it is not wholly infallible and requires to be seconded with other precautionary measures. If tuberculin is infallible, most of the suggestions made fall to the ground as unnecessary, unless the disease can be readily reintroduced by man or diseased animals of other species, a possibility of wholly unknown dimensions at present.

The study of tuberculosis, though prosecuted for many years, still offers many problems of prevention to solve, especially those which pertain to the conditions underlying predisposition. Is the breed or descent of the animal of much importance, or is it the conditions under which each animal is compelled to live which determine the readiness with which the disease destroys the body? These are vital questions, and their answer must have an important modifying influence on the future success of dairying and stock raising. As we are now entering upon an era of suppression of this disease, it should be borne in mind that radical measures are the best to begin with, and that after the disease has been weeded out of each herd by tuberculin one or more times such herds become, in a sense, an experiment in the prevention of this disease, with the element of contagion presumably completely eliminated. The future will then decide how much is to be feared from the lapses of tuberculin, from sources of the virus outside of the bovine species, and from heredity, breed, and environment as predisposing agents.

BOVINE TUBERCULOSIS IN ITS RELATION TO THE PUBLIC HEALTH.

The dilemma in which the demands of public health have put the owner of cattle, as well as the health officer, has already been stated. The following statements referring to this subject are based upon a careful study of the distribution of the disease in a large number of animals. It needs to be emphasized here that arguments deduced from the superficial examination of a carcass and the simple determination of the presence or absence of tuberculosis are worth little or nothing in attempting to solve the problems presented by the sanitary side. Only a thorough survey of the entire distribution of the tuberculous deposits in animals furnishes us with approximately correct data.

The flesh of those infected cattle in which the disease is restricted to one or two primary foci must be regarded as entirely harmless and of full nutritive value. Even in advanced cases, which should always be rejected, the glands embedded in the muscular tissue are found infected only occasionally.

The condition of the milk in different stages of the disease is a question of much greater importance, and demands the most careful consideration. We may, for convenience and clearness, typify three stages:

(1) In the earlier stages of the disease, provided the udder is normal, the milk is free from tubercle bacilli.

(2) In the more advanced stages, provided the udder is normal, the milk may or may not contain tubercle bacilli. If the disease has become generalized, the indications are that at some time or other tubercle bacilli may pass into the milk. This passage is revealed at the autopsy by disease of the glands of the udder. The indications are that this passage is largely temporary, perhaps lasting only a day before the tubercle bacilli are caught up and filtered out into the lymphatic system. The indications are, furthermore, that comparatively few bacilli passed through the udder. The udder itself does not favor their development there, and the closest inspection fails to reveal any augmenting foci of disease. These statements are based on careful examinations of slaughtered cattle and the thorough testing of milk from advanced cases.[1]

(3) When the udder is affected in any stage of the disease, a most grave condition is presented. Tuberculosis of the udder in most cases comes on in the later stages, when the virus is distributed by the blood from some disintegrated earlier focus of disease. Primary tuberculosis of the udder, that is, infection from without, has not yet been established definitely, and is probably of very rare occurrence. When the disease has started in the udder itself, tubercle bacilli may be discharged in

[1] See Bulletins Nos. 3 and 7 of the Bureau of Animal Industry, United States Department of Agriculture.

the milk in large numbers and for long periods of time. The smaller the herd, in such a case, the more dangerous the entire milk becomes, because of the concentration of the virus.

Udder tuberculosis is thus a most serious danger, the importance of which can not be too strongly urged. Fortunately, it is rare. The writer has encountered among 200 infected animals only one case of udder disease, and 16 others which, according to the post-mortem studies, may have shed at one time or another tubercle bacilli into the milk in small numbers, but which had no recognizable disease of the udder itself. The large percentage of udder tuberculosis reported by several writers lately is incompatible with all former statistics, and indicates either an unprecedented condition in certain localities or else an error in diagnosis. The stock owner, in the absence of proper dairy or other official inspection, is under serious moral responsibilities to remove from his herd those animals in which there is even a suspicion of udder tuberculosis. Any udder which is found to increase slowly in size without any indication of inflammatory processes, recognizable by the presence of heat, pain, and redness, and which becomes very firm without showing at first any alteration in the appearance of the milk, should be regarded as infected, the cow promptly segregated, and the entire milk rejected until a diagnosis can be made by a veterinarian.[1]

In view of the fact that tuberculin does not discriminate between dangerous and harmless cases, the public-health problem as it presents itself in practice is simply this: What shall be done with all the cattle which give the tuberculin reaction, in order that we may catch and destroy the 10 per cent[2] of slightly and temporarily dangerous cases among them, or the 1 per cent[2] of serious cases? Some of the dangerous cases are so far along in the disease that they are easily detected without the aid of tuberculin, but this is by no means true of the majority. The situation certainly demands a most rigid periodical inspection of all animals furnishing milk to consumers, the prompt removal of all suspicious cases, and, above all, a more thorough control of the dairy in the interests of public sanitation.

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[1] The stock owner needs here to be reminded that the feeding of milk from a tuberculous udder to calves and pigs is the most dangerous thing he can do in laying the foundation of lifelong tuberculosis in young animals.

[2] These figures may be too high or too low. The collection of further accurate statistical evidence is needed.

THE PASTEURIZATION AND STERILIZATION OF MILK.

By E. A. de Schweinitz, Ph. D.,

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Of all the food and drinks of man there is perhaps none which is more important than perfectly pure, clean, and healthy milk, and to secure it should be the subject of earnest care. The fact is well known that milk undergoes a number of chemical changes in its constituents some hours after milking. It becomes sour, owing to the decomposition of the milk sugar, the casein separates, and finally putrefactive decomposition begins. These changes are induced by the presence in milk of bacteria, which for the most part do not generate diseases, but which may be, and often are, accompanied by bacteria capable of causing disease that obtain access to the milk from the body of the animal, from the air, from the water that was used to wash the cans, from the hands, clothing, and person of the milker, and the like. Even when collected with precaution, the careless distribution of milk may result in its contamination with disease-producing bacteria.

The responsibility of milk for the distribution of a large amount of tuberculosis is at present more thoroughly appreciated than heretofore. To milk is also attributed the spread of typhoid fever, cholera, diphtheria, and other diseases, not to mention the many troubles peculiar to children that are to be traced directly to an impure milk supply. The latter are especially frequent in the crowded tenement districts of cities, where, through ignorance and lack of cleanliness, young children are surrounded by the worst possible conditions.

It is safe to assume that most of the ordinary bacteria found in milk gain access to it from the dirt of the udder, or some other portion of the animal, and when we remember that the fæces are largely undigested food which is filled with an enormous number of bacteria, it is easy to see how easily milk becomes contaminated. The character of the bacteria in milk is also influenced by the straw used for littering, depending upon whether this is fresh and often changed, or whether it is already fermented and only occasionally changed. The dust from the earth and stalls will naturally also make a great difference in the purity of milk.

An idea of the amount of dirt and bacteria in milk can be obtained from the following figures: Renk found an average of 0.015 gram of fæces in 1 liter of the milk sold in Halle, Germany; in that of Berlin, 0.010 gram to the liter, and of Munich, 0.009 gram to the liter (0.1386 grain to the quart). The maximum contamination in the milk in Halle

was 0.3625 gram of fæces to the liter. A good idea of the purity of milk may be had by ascertaining the number of bacteria it contains. This number has been found to vary from 10,000 to 100,000 per cubic centimeter immediately after milking, and increases enormously after standing for a few hours at the normal temperature. The first portion of the milking contains the largest number of bacteria per cubic centimeter, the last portion often none at all. If kept on ice the germs do not multiply. The bacteria which produce lactic acid and those which produce butyric acid are most common. The latter, together with certain spore-bearing bacilli present in the dust of the air, are the most difficult to contend against. It is apparent, of course, that some of this contamination can not be avoided.

The importance of a method or methods of freeing milk from these minute forms of life which cause so much damage, or of rendering them harmless, is evident. Several methods have been adopted to secure this end. The three most important are the use of chemicals, pasteurization, and sterilization, all being employed with the view of destroying the germs without injuring the properties, value, and healthfulness of the milk.

PRESERVATION WITH CHEMICALS.

Bicarbonate of soda is often used for this purpose; but, though this will neutralize the acidity, it rather favors than retards the increase of bacteria. Boric and salicylic acid are of some use in this connection, but both have been found to be injurious to health, even in small doses, if taken continuously. These and other chemical means are therefore neither satisfactory nor advisable.

The cooling of milk is well understood, but the most advantageous method of preserving it is by pasteurization or sterilization. In pasteurization the milk is warmed to 65° to 70° C. (155° to 160° F.), a temperature sufficiently high to kill the ordinary bacteria and pathogenic germs. There are a few germs, however, which can only be destroyed by heating the milk to the boiling point, the temperature of complete sterilization, and to these we will again refer under the head of sterilization.

PASTEURIZATION OF MILK FOR CHILDREN.

Dr. Koplik says, in an article to which we will again have occasion to refer, that in his experience in the city of New York he has seen children flourish amidst the most unfavorable surroundings when their food and milk supply was derived from his dispensary, where it was thoroughly pasteurized under proper conditions, while in the same districts other children which were left to the carelessness of the mother were sick and puny.

In addition to pasteurization, milk may be specially adapted for feeding to children and invalids by the addition of albuminoids and milk sugar. This makes it more nutritious and constitutes the so-called rec-

tified milk. The simple pasteurization of milk is useful, provided the milk is immediately cooled and used within twenty-four hours. If not afterwards cooled the pasteurization seems to increase the liability to fermentation. In thorough sterilization the danger to be avoided is the coagulation of the albuminoids or burning of the milk. Some authorities claim that the sterilization makes the milk too indigestible, while others claim that the digestibility is not affected, provided the sterilization is properly conducted and the milk is thoroughly stirred during the process. The latter process requires more care than the former.

Pasteurization can be easily carried on by any housewife. A simple and easy method is the one described in a circular issued by this Bureau, and which is here again printed:

The simplest plan is to take a tin pail and invert a perforated tin pie plate in the bottom, or have made for it a removable false bottom perforated with holes and having legs half an inch high, to allow circulation of the water. The milk bottle is set on this false bottom, and suffi-

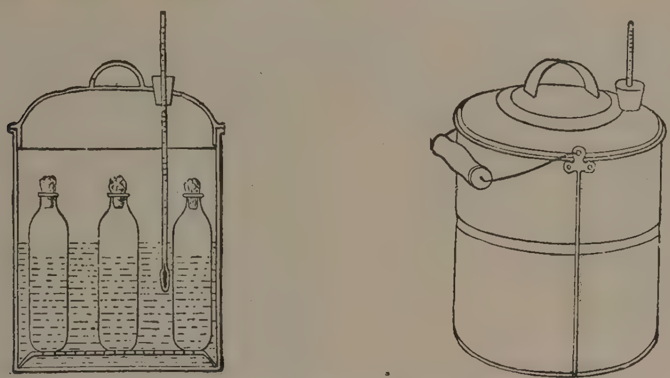

FIG. 52.—Sterilizing apparatus used in the Bureau of Animal Industry.

cient water is put into the pail to reach the level of the surface of the milk in the bottle. A hole may be punched in the cover of the pail, a cork inserted, and a chemical thermometer put through the cork, so that the bulb dips into the water. The temperature can thus be watched without removing the cover. If preferred, an ordinary dairy thermometer may be used, and the temperature tested from time to time by removing the lid. This is very easily arranged, and is just as satisfactory as the patented apparatus sold for the same purpose. The accompanying illustrations show the form of apparatus described (fig. 52).

PREPARATION OF MILK FOR INFANTS AND INVALIDS.

In the New York Medical Journal, February 4, 1893, Dr. Koplik describes the method used by him for several years in the Good Samaritan Dispensary in New York for the preparation of infants' food. The milk supply is derived from a reliable leading dairy and delivered in refrigerator tubs. This is a point of special importance to which we

will again refer. After many experiments and a comparison of results obtained by others, Dr. Koplik has found the most satisfactory temperature for the sterilization to be 85° to 90° C. At this temperature there is a slight deposit of casein upon the sides of the bottle. Above 90° C.

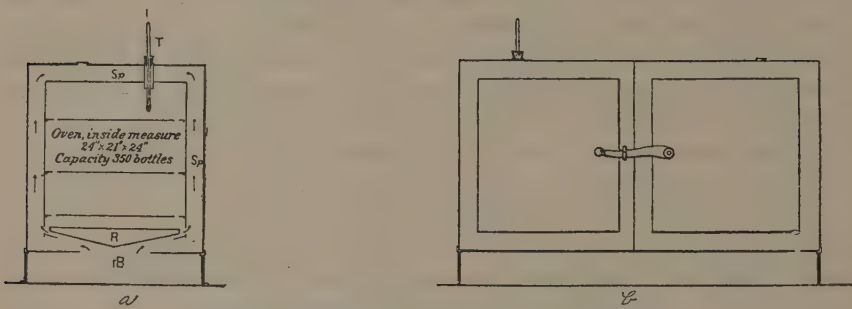

FIG. 53.—The Koch oven—interior and exterior views.

the milk presents a boiled appearance and flavor, and the butter rises and floats on the top. In the plan adopted by Dr. Koplik, bottles of different sizes are used, 2 and 4 to 5 ounces, just sufficient for one nursing, so that the return of the bottle insures a thorough sterilization of the sample for a repeated dose. The bottles are first filled with a saturated solution of soda and allowed to soak for twelve hours, and then thoroughly washed with a brush, both outside and inside, rinsed with pure water, and allowed to drain and dry.

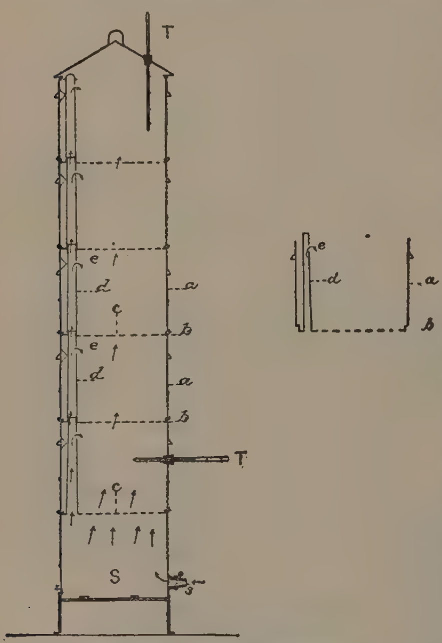

FIG. 54.—Koplik's pasteurizer.

After this they are heated in a Koch oven (fig. 53) to a temperature of 160° to 170° C. for forty minutes. They are then allowed to cool and are ready for filling with milk. The apparatus for sterilization is made of stout block tin and divided into five compartments and a steam box. The compartments are furnished with perforated bottoms and fit one on top of the other, forming a compact column (fig. 54) through which the steam can permeate. Each compartment will hold fifty large-sized bottles. A thermometer passes through the cover of the top compartment and dips into the milk, so that the temperature can be noted. A stout tin pipe runs the whole

length of the sterilizer and dips into the top of each compartment, in order to fill the compartment uniformly with steam. The bottles, filled with the desired quantity, are placed uncorked in each compartment and covered with a cloth of clean flannel. When the milk has reached a temperature of 85° C. the process is continued for half an hour. The bottles are then taken out and rapidly corked with sterile rubber corks.[1] The whole process is completed in an hour. The milk used is always carefully examined. It must have 12 to 14 per cent of cream, and when boiled should not coagulate. The coagulation indicates the beginning of fermentative changes. Sometimes milk which tastes sweet will turn almost solid on boiling, showing that advanced changes have taken place. The slight acidity which would admit of detection only by chemical means would be apparent on boiling by the curdling of the milk. A little experience will enable one to detect the difference between the coagulation due to acidity and that ordinarily present after sterilization of good milk. The milk is bottled from large glass percolating funnels, thus requiring very little handling. For sick infants the diluent for the milk, a 4 per cent solution of milk sugar, is furnished. Limewater, as supplied by the drug stores, may also be used. If barley water is used as a diluent, it should be very carefully prepared and the milk diluted by an expert. Leaving the barley water to be prepared by the ignorant, or using barley water made from poor material, leaves open too many chances for infection. During two seasons Dr. Koplik states that 1,268 children were supplied with the milk from his laboratory; 729 infants received the milk for only one or two days, while 539 received it for from one week to five months. About 400 of the latter he thinks were really benefited by the use of the milk.

This apparatus could be adapted for sterilizing milk in larger bottles and in greater quantity.

In Boston and New York private laboratories have been established for the purpose of rectifying milk, as it is called. These laboratories supply pasteurized milk on physicians' certificates, or milk to which has been added peptone, sugar, or other material as the physician may direct. The bottles, about 8 ounces in capacity, after being thoroughly cleansed, are plugged with cotton and then sterilized. They are then filled with the milk, pasteurized directly with dry steam in a rectangular box especially arranged for the purpose. After pasteurization the bottles are packed in wooden cases lined with ice, so that the milk can be kept cool and shipped to any desired spot. This method is similar to the one recommended by the Bureau, and can also be readily conducted by any housewife, either with the use of the vessel described or an Arnold steamer.

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[1] The corks are of black rubber, and are sterilized by boiling for an hour in the solution of soda, rinsing with water, and sterilizing with steam. When the corks become brittle they are rejected.

Many different forms of apparatus for pasteurization in stoppered bottles have been recommended in Europe, the simplest being the use of beer bottles with the ordinary patent stoppers.

The sterilization or pasteurization of milk in bulk is a matter of great importance, to which much attention has been paid abroad, but comparatively little in this country. A pasteurizing apparatus invented by Professor Fjord and used in all creameries in Denmark is described here (fig. 55).

A copper cylinder, covered with tin, is fitted steam tight into a larger vessel, made of copper or galvanized iron and covered with wood to retard cooling. The steam is introduced through the opening at *g* and passes out through *d d*. The milk or cream enters at *c* and passes out at *e*. This exit tube has a pocket into which a thermometer can be placed, so that the temperature can be controlled. The agitator, *a*, is of wood or metal, connected to a shaft, so that it will make about 150 revolutions per minute. The temperature used varies between 160° and 180° F. In some dairies in Denmark the sweet milk is pasteurized. In others the cream is sterilized and then cooled before being set aside to ferment. In nearly all cases the skimmed milk which was returned from the cooperative dairies to the producers was sterilized as it left the separators. In this way it would keep better, and when fed to calves all danger from infection with tuberculosis would be avoided. If sweet milk is sterilized, the separator skims it cleaner, but the sterilization very slightly diminishes the amount of butter, as a little more fat is left in the buttermilk. On the other hand, the sterilization of cream before churning will give a more uniform and better butter.

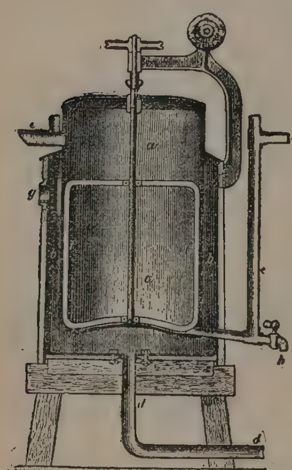


FIG. 55.—Fjord's pasteurizing apparatus.

In the city of Posen,[1] Germany, a satisfactory method of supplying sterilized milk in quantity and cheaply has been adopted. After washing the teats of the cows thoroughly, the animals are milked with care, the milk collected in metal vessels, centrifugalized twice, and placed in flasks of 100 to 400 grams capacity, respectively. Soxhlet's patent stoppers are used.[2] The milk is then placed in metal casks heated by steam, the steam having a temperature of 104° C. in winter and 104½°

[1]Hesse. Zeit. f. Hygiene, vol. 13, Hft. 1, p. 42.

[2]Soxhlet's patent stopper consists of a rubber cap which fits over the top of the bottle and acts as a ventilator to relieve the inside pressure of the bottle, and prevents the outside air from entering the flasks. It is held in place by a metal cap which prevents it from slipping. The bottles are heated for thirty-five minutes in a water bath. After the flask is once opened it should never be used again without resterilization, as the removal of pressure loosens the cap. (Fig. 78, *a*, p. 355.)

in summer. A higher temperature causes coagulation of the casein and makes the milk indigestible for children.

For sterilizing milk, in 1892, Ockonomie-Rath Grob, in Berlin, used flasks with patent beer stoppers, and this has since been recommended by others.

In Dresden, milk is sterilized in large quantity in the following manner: The firm draws its supply from a large estate in the neighborhood. The animals that supply the milk have only dry fodder, and every attention is paid to the cleanliness of the stalls, apparatus, and hands of the milkers. The milk is cooled to a temperature of 10° to 12° C., and reaches the creamery two or three hours after its collection. It is first freed from dirt by a specially constructed centrifugal machine, then warmed to 65° C. and collected in a vessel from which it is finally transferred to sterilized flasks with patent stoppers, holding one-third liter. These flasks are then placed in a sterilizing case and submitted to the action of steam for one and three-quarters hours. They are then removed and quickly cooled to prevent burning. The milk prepared in this way can be readily used. During a year, out of 70,000 liter flasks that were sterilized and subsequently placed in an incubator for the purpose of testing the sterilization, only 63½ were found spoiled.

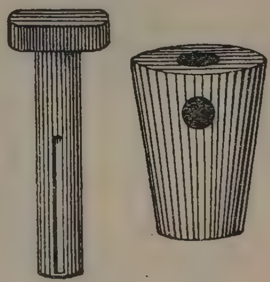


FIG. 56.—German sterilizer stopper.

As the milk would seldom be subjected to this temperature (that of an incubator), but would generally be used within a day or two after sterilization, it is not likely that a flask of spoiled milk would be obtained.

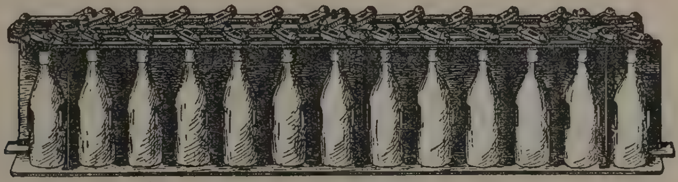


FIG. 57.—German sterilizing flasks.

One of the principal points to be desired in sterilizing milk is that it can be done in flasks or cans that in turn may be transported for a considerable distance without danger of the milk becoming contaminated. In order that this may be the case, the milk should be sterilized or pasteurized in flasks that admit of being tightly closed. An arrangement for this purpose, which is used in Germany and very highly recommended, consists of a rubber stopper with a central hole and side opening, and a nail-shaped glass rod with a side slit, as indicated in figure 56, and the whole sterilized in a closed box, as shown in figures 57 and 58.

After heating for three-quarters of an hour, the flasks are opened by means of the parallelogram crank, so as to relieve the pressure, and then closed. After heating again, the flasks are carefully removed and the glass stopper forced into the cork, so as to entirely close the bottles. The taste of the milk is not at all changed, and side by side with fresh milk it is impossible to tell the difference.

Pasteurization in the household, whether according to Soxhlet or the Bureau, is open to certain objections. In the first place, considerable time is required for keeping the vessels clean, which is one of the essentials, and this should be done by someone who appreciates the importance of the process. It requires more time than a housewife could conveniently afford, and if left to a servant, the probability is that the importance of the process will not be appreciated, and may consequently be carelessly carried out, or even, after a while, be entirely neglected. For this reason it would be better to have the milk reliably sterilized in bulk and so distributed. This should be done under the direct control of someone who understands the purport and importance of sterilization and can make the necessary examinations of the milk, not only as to the proper fat contents, purity, etc., but also as to its freedom from germs after sterilization.

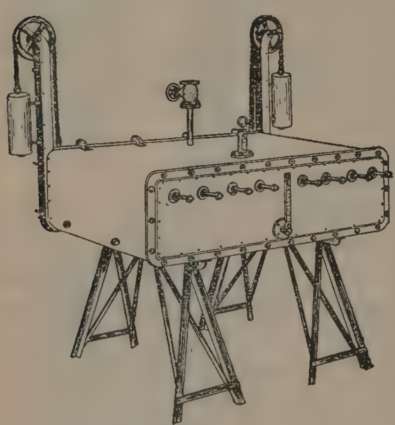


FIG. 58.—German sterilizer.

PASTEURIZATION OF MILK IN BULK, IN SMALL FLASKS OR CANS, IN AMERICA.

In addition to the preparation of milk for infant food as already described, a beneficent work has been undertaken in New York by Mr. I. Straus, for the purpose of supplying milk to the poor. The milk is prepared in a temporary laboratory on Third street, and is distributed in bottles from a number of different booths in the city. The milk in the cans is obtained from the Appleberg Hygienic Milk Company, of Dutchess County, N. Y. In the plant of Mr. Straus on Third street the process of sterilization is similar to that described above, but it is here repeated. The bottles, of tough glass, 6, 8, and 18 ounces capacity, are first boiled in borax water, thoroughly rinsed, and then sterilized in large Koch ovens. After sterilization they are filled with the milk and placed in copper holders (fig. 59). These are then placed in the sterilizers, which are the ordinary kitchen stove boilers (fig. 60). The boilers are filled with water, which can be heated either by steam or by a gas flame under the boiler. The cases are filled with water up to the

shoulder of the bottle. The water is heated and the bottles then placed in the boilers and allowed to remain for half an hour. At the end of this time the lid is carefully raised and gradually pushed around, so as to expose the mouths of only a few bottles at a time, and these are then quickly corked with solid black rubber stoppers which have been previously sterilized by boiling in borax or soda solution. The bottles are then taken out, cooled on ice, and distributed. Instead of these boilers for sterilization, there is sometimes used a large oven with water bottom, which is heated by steam, and the bottles are placed on shelves above, so that they do not come directly in contact with the steam. For dilution filtered water is used, and for further preparation barley water or limewater.

The process is under the supervision of two physicians, who examine the milk used and see that proper precautions are adopted. The for-

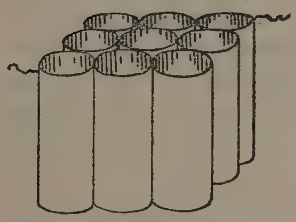


FIG. 59.—Copper holders used in Straus's plant.

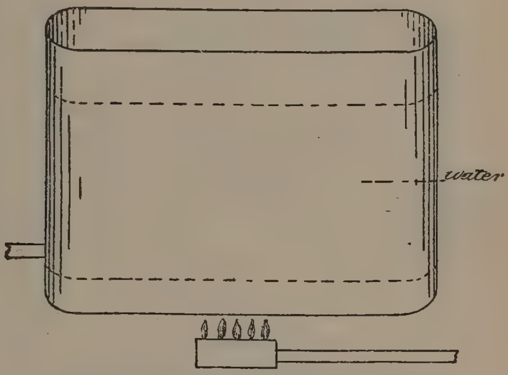


FIG. 60.—Copper boiler used in Straus's plant.

mulæ used for diluting the milk, as taken from the printed slip of the company, are as follows:

Formula 1.

Sugar of milk	ounces	12
Limewater	pint	½
Filtered water up to	gallon	1
Milk	do	1

Formula 2.

Milk	gallon	1
Barley water	do	1
White sugar	ounces	10
Table salt	do	¼

After being thoroughly mixed, the diluted milk is drawn into bottles, pasteurized as above, and sold for 1 cent per 6-ounce bottle. The bottles are returned and, after thorough cleansing, used again.

The milk is obtained from cows which have been inspected and pronounced free from disease. The prices at which this milk is sold are

not intended to bring any profit, but serve to partly defray the expenses of preparation.

Prices.—Raw milk, 4 cents a quart, 2 cents a pint, 1 cent a glass; pure milk, sterilized, 1 quart in four 8-ounce bottles, 5 cents; pure milk, 1 quart in two 16-ounce bottles, 2 cents; diluted sterilized milk (6-ounce bottles), 5 cents.

Deposit required on bottles.—Eight-ounce bottles, 3 cents each; 6-ounce bottles, 3 cents each; 16-ounce bottles, 5 cents each.

The prepared milk is guaranteed for twenty-four hours. It will, of course, keep longer, but this is the length of time that may be safely allowed, when the milk is given into so many different hands.

The principal plant for the pasteurization of milk in large quantity and in bulk is conducted at Pawling, Dutchess County, N. Y., by the Appleberg Hygienic Milk Company.

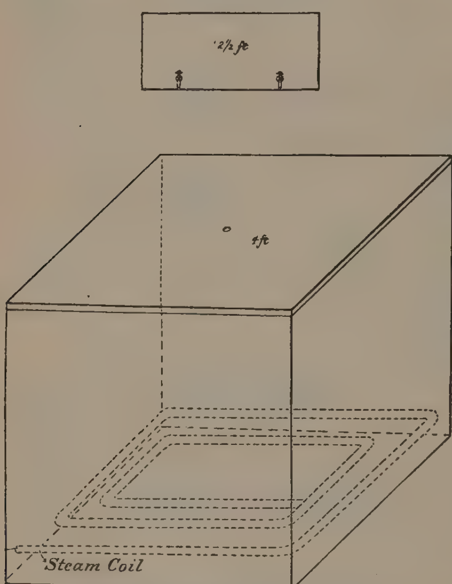


FIG. 61.—Appleberg's sterilizing box.

Pawling is situated near the center of one of the richest dairy counties of the State, so that the supply of milk is the best obtainable. When the milk is received at the factory any mechanical impurity is removed by straining and the whole is then aerated and cooled.

The apparatus for pasteurization (fig. 61) is patented. It consists of a wooden box about 4 feet square, with a hinged lid, and inside of the box is a coil of iron pipe to supply the heat. The milk is placed in rectangular tin boxes of a capacity of 40 quarts, covered with a perforated tin lid to permit the insertion of a thermometer by which to regulate the temperature. These rectangular boxes closely fit inside the coil. The box is then closed and the steam turned on for twenty to thirty minutes, depending upon the milk and the season of the year. During the process the milk is kept thoroughly stirred. The temperature used varies from 160° to 180° F. The milk so pasteurized is then drawn while hot into the ordinary sterilized milk jars, or fruit jars with a flat top. Instead of a rubber washer, one of special paper is used. The jars are filled with hot milk and then set in troughs of ice water to cool. The contraction of the milk upon cooling creates a vacuum in the jars, which are thus hermetically sealed by the outside air pressure. In addition to the bottled milk, this company also puts up sterilized milk in 40-quart cans. The top of the can is closed with a patent lever, something on the principle

of a beer-bottle stopper lever. As these cans are filled while hot, they are also hermetically sealed. At the bottom of the can is an opening for the insertion of a faucet, which can be kept closed by a sterilized cap. When the milk is to be used, the can is turned upon the side and the faucet, previously carefully sterilized, inserted. The milk can be safely used from the can if proper care in cleaning the faucet has been observed. This milk is on sale at some of the booths in New York City, supplied by Straus. The milk, which the writer has had the opportunity of tasting at the factory, is very rich and most delicious, and without a particle of boiled or cooked flavor. As the cream and milk have been thoroughly mixed, it tastes more like pure cream.

At Danby, N. Y., there is also a plant for sterilizing milk in bulk, hot water being used instead of dry steam. The Appleberg method seems to give the most satisfactory results.

In Boston, in addition to the laboratory for sterilized milk, there is some work in the distribution of pasteurized milk from one of the church dispensaries. There is in that city a careful milk inspection, but no sterilized milk is sold in quantity, so far as I was able to learn from the milk inspector. In Brooklyn, also, there is a very careful chemical and veterinary milk inspection. The city is divided into districts, which are gone over carefully. It is required that the milk shall have 12 per cent solids and 3 per cent fat. In New York during the past summer less adulteration has been found than usual. In none of these cities, however, is especial attention paid to the milk supply with reference to city control of pasteurized or sterilized milk.

EFFECT OF STERILIZATION ON DIGESTIBILITY.

If the milk is heated to such a temperature that the albuminoids are coagulated, it loses its flavor and acquires a boiled taste, and is neither so digestible for children or adults, nor is it so attractive in appearance. When properly pasteurized or sterilized, however, the taste is not in any way impaired and it is quite as digestible as the raw milk.

To insure a thoroughly healthy supply, all the milk should be under the control of the State and city boards of health. This should include an inspection of the animals themselves, of the stalls, feeding, water supply, methods of milking and saving of the milk. Not only should the animals be perfectly healthy, but the stalls should also be kept thoroughly clean, well whitewashed, and from time to time disinfected by means of carbolic acid. The stalls should also be well ventilated and so situated that the sunlight will be admitted. Attention should be paid to the health of the attendants, and expectoration about the stalls should be prohibited. Only the best clean fodder should be used. In milking, care should be taken that the teats of the animals are clean, and the utmost neatness and cleanliness of hands and clothing should be observed on the part of the attendants about the stables. Instead of selecting particularly old and dirty clothing for the milking, only clean,

washable overalls should be used, and these should be kept exclusively for that purpose.

The water supply is often of as much importance as other precautions. There is no reason why the lower domestic animals should not be supplied with good water, and there are many reasons for believing that an impure supply is injurious. The necessity for pure water in the dairy is well illustrated by the following incident: In a certain dairy the utmost care was observed in cleaning and scalding the milk cans. However, just before the cans were filled, they would be rinsed with cold water from the well. This well was situated near the stalls, so that it received the drainings and washings from the manure, and while the well ordinarily, perhaps, was in good condition, it was at any time liable to contamination by typhoid fever and putrefactive bacteria. The simple rinsing of the cans was sufficient to destroy all the good effects of the previous care.

A company in Copenhagen, Denmark, and one in Stockholm, Sweden, pay considerable attention to securing a good milk supply, thus to some extent replacing the boiling of milk.

Although by the order of 1885 a person suffering from any dangerous disease, or who has recently been in contact with a person suffering from a dangerous disease, is prohibited from participating in the production, distribution, or storage of milk, in country districts this law can be easily evaded. The regulations of the two companies above named require—

(1) Veterinary control of all the animals on the farm and exclusion of the milk from unhealthy cows.

(2) Cooling of the milk by ice to 41° F. at the farms.

(3) Filtration of the whole milk through fine gravel.

(4) Absolute cleanliness of all the bottles and cans used.

The company has in its employ seven veterinarians, one of whom devotes his time to visiting the farms in rotation. Of course, where there are many animals it is difficult to inspect all at one visit, but each animal is examined carefully once a month. Special attention is given to the examination of the udder and adjacent glands. If a tuberculous cow is detected, it must be at once separated, or if the health of a cow appears bad, it must be withdrawn for a time. The farmer is bound to report any case of illness occurring in the interval of the veterinarian's visit, and to withhold the milk until he arrives. Stall feeding is prohibited, except in winter. Infectious or contagious disease in the employees must be at once reported, and the milk supply they have handled kept back. The greatest cleanliness in milking must be observed, and the milk, after being strained, is at once cooled to 41° F. by ice.

In winter the food consists of rape-seed oil cake, hay and straw, and brewers' grain, while anything that might give the milk an unpleasant taste, such as turnips, is excluded. This care and precaution on the

part of the farmer is secured by the company agreeing to pay a proportionately larger price for the milk, and even paying for the milk if it is not used. The carefully collected milk is tasted and sampled from every cow, and then filtered through gravel in perforated tin trays (fig. 62). In the lowest tray the gravel is the size of a split pea—in the highest, of a pin's head. Three thousand bottles are filled every evening, and the milk guaranteed for twenty-four hours. Cream may also be treated in the same way. Soda is used for cleaning the cans.

In addition to this filtration, the milk may be pasteurized. This is done by placing the bottles in racks in a long trough filled with water. A coil of steam pipe heats this water to 75°, when a contact thermometer rings a bell, the signal for shutting off the steam. The milk is then allowed to cool to 60° C., then taken out and put on ice. The company has daily analyses made, and these are published monthly.

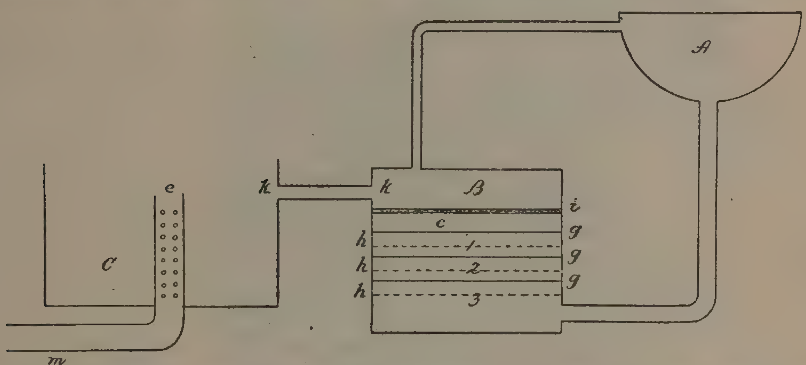


FIG. 62.—Milk filter. *A*, tank; *B*, filter; *C*, storage tank; 1, 2, 3, perforated metal trays to hold gravel; *g g g*, india-rubber rings to protect enamel; *h h h*, galvanized rings; *i*, 5-ply filter cloth of close texture, surmounted by 1-ply of fine texture; *k k*, pipe to carry off milk from the filter; *e*, perforated pipe, so as to draw milk from every part of the tank to the bottling room.

In Stockholm controlled and uncontrolled milk are sold. The company has built two large cow sheds. The walls, floors, and troughs are cemented; the buildings well lighted and ventilated. The cows are kept in sheds throughout the year. A number of men are employed in continually cleaning the animals and removing the refuse. There is no odor about the stalls, as this is all absorbed by the peat. Before milking, the floor is swept perfectly clean, the milkmaids must wash their hands, wear special aprons, and carefully clean the udders. The cans are washed with boiling water and the milk strained through muslin and fine copper gauze, and then cooled. A veterinary surgeon lives on the place, and the cows are always sold after a year or two, so as to keep fresh milkers all the time. The finest and healthiest cows are reserved for children's milk. By isolating the calves of tuberculous animals and feeding them on boiled milk Professor Bang has succeeded in keeping them free from disease, and has carried out a number of experiments on large estates. He also emphasizes the fact that small herds are rarely tuberculous.

DIFFERENT FORMS OF APPARATUS.

A great many different forms of apparatus for the pasteurization or sterilization of milk in bulk have been used abroad, and the description and figures of some of these, partly reproduced from Weigmann's report, are here given. Many are unnecessarily complicated. The simpler apparatus gives equally satisfactory results.

One of the first pasteurizers in bulk to be used was a continuous-working apparatus, and consisted of a double-walled copper cylinder,

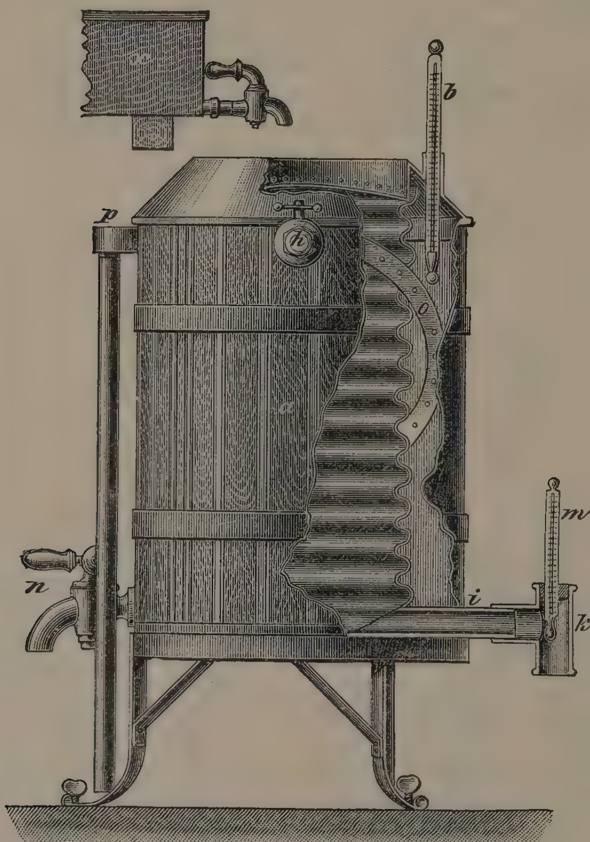


FIG. 63.—Thiel's pasteurizing apparatus.

which could be heated by steam. The form now used is practically unchanged. The milk flows in at the top, is kept thoroughly stirred by means of a crank at the bottom, and flows out from the side, near the top, at a temperature of 70° to 80° C. The stirring apparatus prevents the burning of the milk and also the separation of the casein.

In 1886 Thiel recommended the following apparatus (fig. 63): An outer sheet-lead mantle, lined with wood, *a;* an inner tinned corrugated copper cylinder, *b*, with a lid, *c*, which fits tightly over both. The water

used for heating enters through h, and circulates, by means of a pipe, in the space between the outer and inner cylinder, p serving as an escape pipe. The milk flowing over the corrugated sides is heated and escapes through i and k at a temperature which can be noted by a thermometer placed at k. The milk reaches a temperature of 60° C., and its taste and appearance are good. Experiments have shown that milk treated in this apparatus will keep two or three days longer than that which has not been pasteurized.

Another apparatus, Hochmuth's, is a combination of a warming, pasteurizing, and cooling machine (figs. 64, 65, 66, and 67). This may be constructed so as to be placed either in a vertical or a horizontal position. Pasteurization is accomplished by means of steam pipes, the steam circulating between the coils through which the milk flows. This apparatus, however, offers the objection that the milk is too easily burned on the coils and the apparatus is one difficult to keep clean.

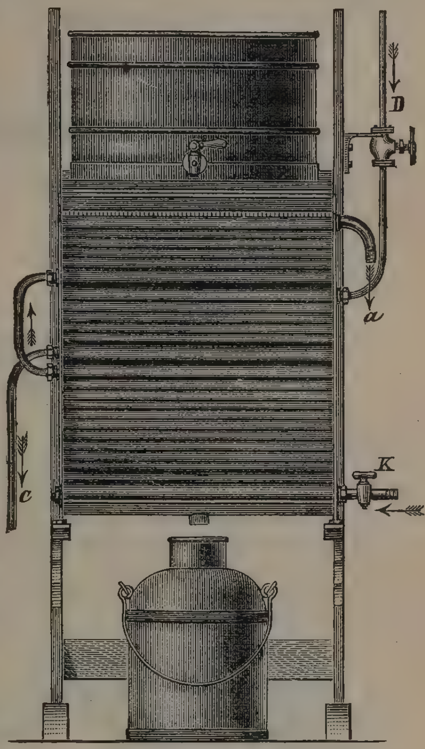


FIG. 64.—Hochmuth's pasteurizing apparatus.

Fjord's apparatus, already illustrated in figure 55, avoids these troubles. Some modified forms of this are seen in Ahlborn's apparatus (figs. 68 and 69).

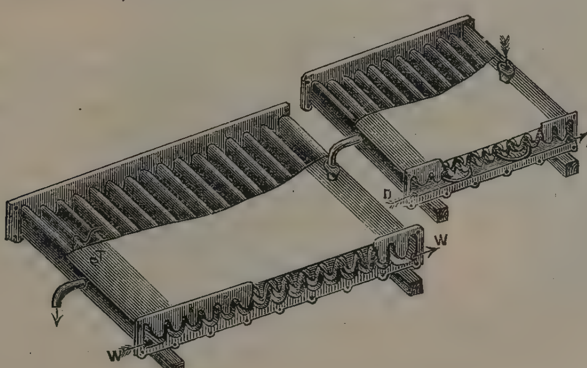


FIG. 65.—Section of Hochmuth's pasteurizing apparatus.

Another similar apparatus, made by the Bergedorfer Iron Works, shown in figure 70, differs from the others mainly in the way the milk

is introduced. The cold milk, in entering, is warmed by the volume of milk already pasteurized.

The apparatus shown in figure 71, constructed by Dierks & Möllman, in Osnabruck, is intended especially to prevent the burning of

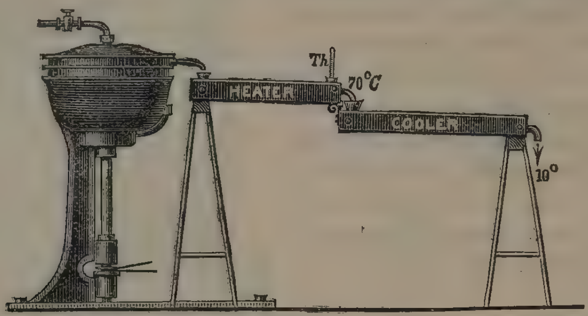


FIG. 66.—Hochmuth's pasteurizing apparatus, with parts arranged horizontally.

the milk. It consists of an outer box, lined with wood. Within this is a cylinder provided with a removable top, and within this a second cylinder which leaves between the two but a small space. The milk is forced mechanically through the space between these cylinders, and at the same time is heated by the steam surrounding the outer cylinder. The burning of the milk is prevented by means of a stirrer provided with arms which make twenty-five to thirty revolutions per minute, and in every revolution they come in contact four times with each portion of the milk. In every minute each particle of milk is agitated one hundred and twenty times, thus entirely preventing the burning of the milk in contact with the cylinder and the deposition of albumin.

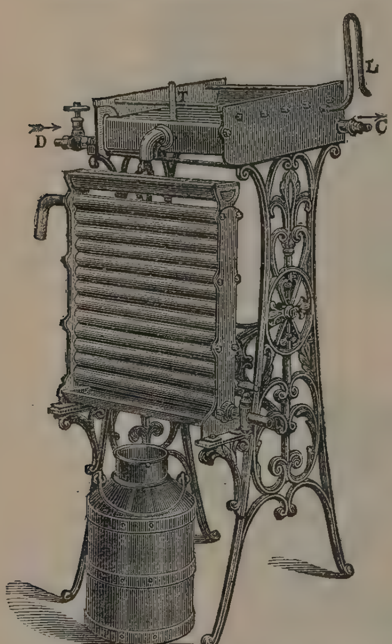


FIG. 67.—Hochmuth's compound pasteurizing apparatus.

Another more expensive apparatus, constructed by Lefeldt & Leutsch, in Schöningen, Germany, consists of a centrifugal which first frees the milk from impurities. As experiments have shown, it is really those bacteria which are ordinarily found in the dirt, particles of fæces, hair, etc., which most easily resist heating, partly because they are mechanically protected by the dirt in which they are found and partly because spores are often present. The removal of these mechanical impurities aids the subsequent pasteurization. Flowing from the centrifugal basket, the milk passes through a narrow

space about 1 inch in diameter, which is heated from the outside by direct steam. This apparatus has the advantage of being compact, utilizing the steam thoroughly, and preventing the milk from burning.

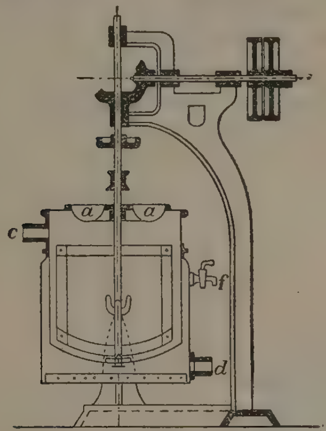


FIG. 68.—Ahlborn's pasteurizing apparatus.

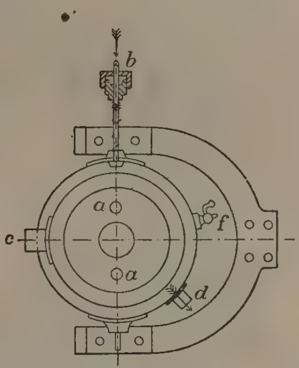


FIG. 69.—Ahlborn's pasteurizing apparatus—modified form.

Five hundred liters (125 gallons) per hour can be pasteurized with this machine at a temperature of 70° to 75° C. (fig. 72).

The many forms of apparatus recommended for the continuous pasteurization of milk indicate that there are always some difficulties, and

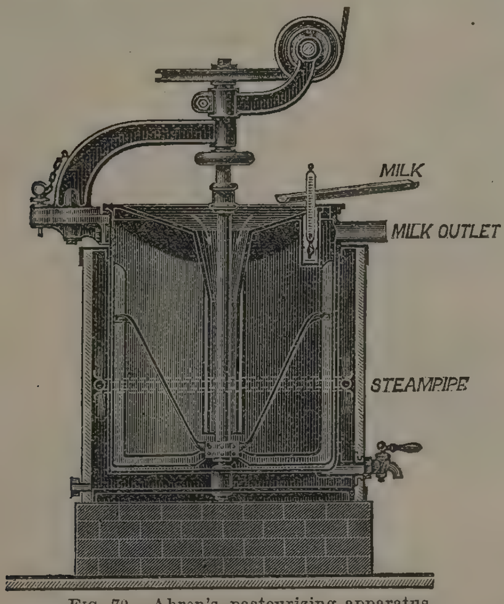


FIG. 70.—Ahren's pasteurizing apparatus.

that the results obtained are not satisfactory. The burning of the milk on the sides of the apparatus, and consequent uneven heating of the remainder, and the temperature used, 70° to 75° C., which ordi-

narily will cause precipitation of some of the casein as well as impart to the milk a burned flavor, are objectionable. To avoid this, Bitter has constructed an apparatus which does not permit of a continuous pasteurization, as in the other described apparatus, but which allows of a longer heating of the milk. In the case of a number of bacteria, especially the tuberculosis bacillus, a temperature of 68° C. for fifteen minutes is sufficient to kill. For certainty, the milk should in all instances be exposed to this temperature for thirty-five minutes. Bitter found, further, that when the milk was heated to 68° for thirty-five minutes, and then cooled to a temperature of 15° C., it would keep fifty to seventy hours longer than that which was not pasteurized. This temperature, when maintained for thirty-five minutes, appeared from his experiments, performed with 40 liters of milk, to be sufficient for the full pasteurization of the milk. Unskimmed milk may be heated for fifteen minutes to 75° C. without any coagulation or burning or any material change in the flavor taking place. This milk, when cooled to 16° C. and saved for sixty hours, did not keep any better than the milk heated for thirty minutes to 68° C.

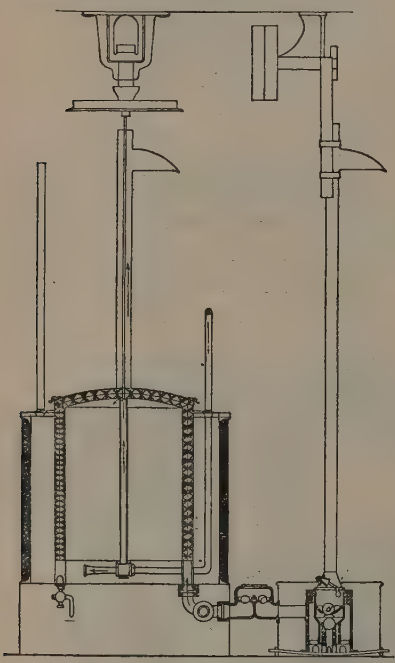


FIG. 71.—Dierks & Möllman's pasteurizing apparatus.

It is of course easily understood that the milk keeps better after pasteurization the more it has been cooled. To demonstrate the keeping properties under the conditions which would actually obtain in practice, Bitter exposed milk which had been heated to a temperature of 75° C., first to 14° C. for ten hours, then to 23° C. for twenty-two hours, afterwards to 30° C. for seven hours. The milk was still good and kept for five hours longer at 23° C. The milk was consequently kept for forty-four hours at a temperature not at all calculated for its preservation. In practice, the milk, before it is sent out from the creamery, is cooled to 10° to 15° C. and then distributed from large cans of 40 liters capacity, and the quantity of the milk, therefore, has considerable influence in keeping it at a low temperature. Milk that has been pasteurized at 75° for fifteen minutes, or 68° C. for 35 minutes, and then cooled, will keep in the warmest summer for thirty hours. If the temperature of the air is lower, the milk will keep longer. Milk heated to 75° C. will keep at a temperature of 18° to 20° C. for sixty-six hours, and at 14° to 16° C. for three days. This milk was

in perfect condition for sale; there was no coagulation or unnatural taste, and its availability for the manufacture of butter was not in any way injured.

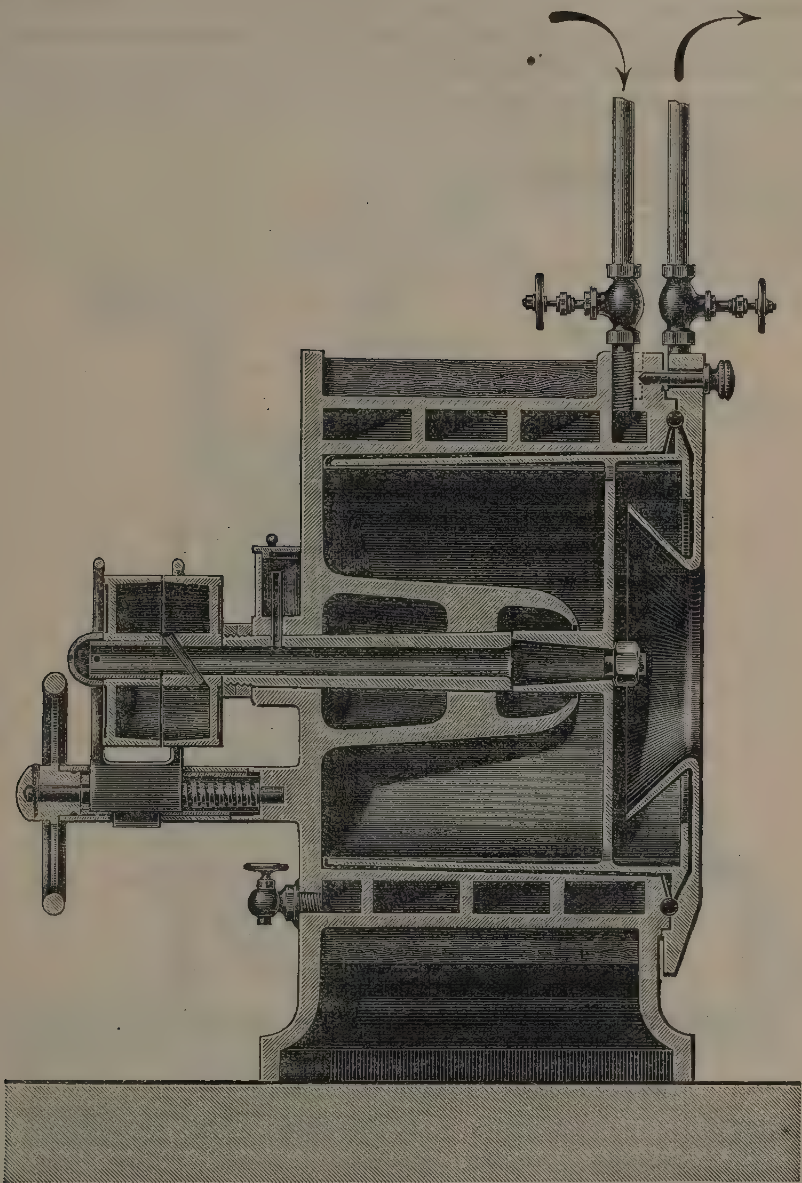


FIG. 72.—Pasteurizing apparatus, constructed by Lefeldt & Leutsch.

The apparatus which Bitter recommends for pasteurization is shown in figure 73.

A tinned copper cylinder, with cap which fits tightly, serves as a receptacle for the milk. About 1 inch from the inner side of this

vessel is a coil of tinned copper pipe which runs to the bottom of the cylinder and then back to the top, the inner coil being narrower than the outer, and from the top of this second coil the pipe returns to the bottom of the cylinder. Through this long coil steam is passed. The milk is kept stirred by an arrangement of paddles which can be readily understood from figure 73. It is very important that the entire pasteurizer and the cans shall be kept thoroughly cleaned. From this pas-

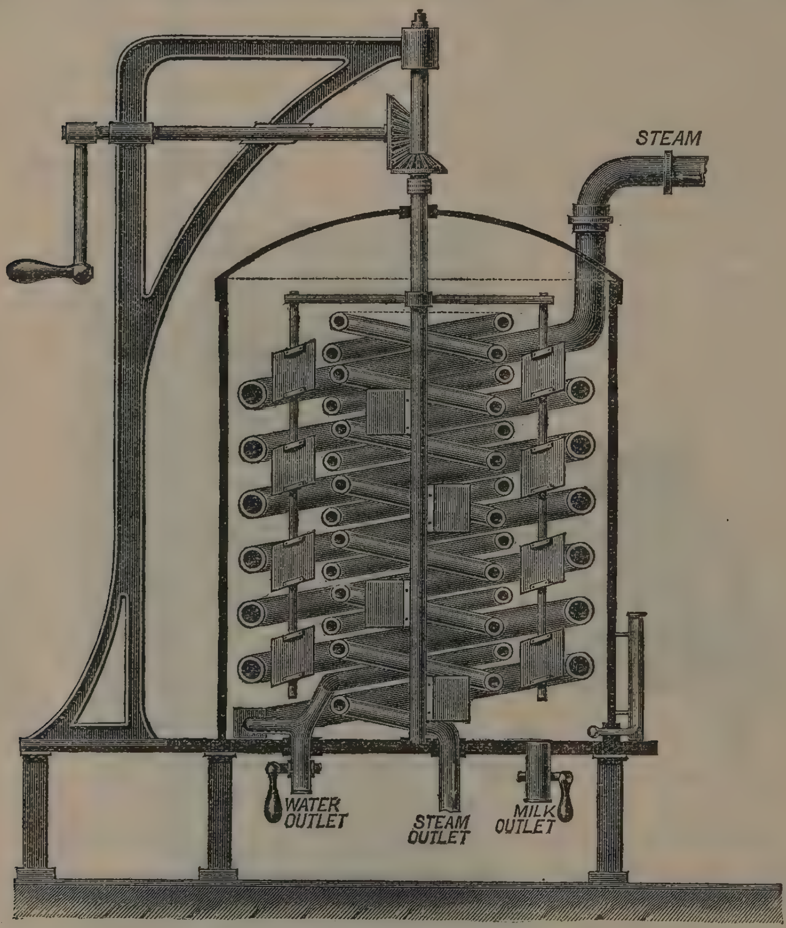


FIG. 73.—Pasteurizing apparatus—after Bitter.

teurizer the milk is allowed to pass through a cooler, as seen in figure 74. This is always thoroughly cleansed and then exposed for a short time to the action of steam. If the hot milk is very quickly cooled, its keeping properties are increased, as any bacteria which might still be present are either killed or so weakened by the sudden change of temperature that a long time would be required before they could again multiply.

STERILIZATION OF MILK.

As already noted, while the temperature of pasteurization, 65° to 70°, is sufficient to kill all disease-producing bacteria, there are a number of germs which are not affected by this temperature, especially the spores, and some which even multiply readily at 70° C. While these latter are not apt to be present in the milk, they may come from the water or dust of the air. The temperature necessary to totally destroy all of these is often over 100° C. (for example, *Bacillus subtilis*), and it must be maintained for a considerable time. This temperature would necessarily injure the taste and appearance of the milk. In laboratory practice it is possible to obtain a thorough sterilization by an interrupted heating. If the milk is heated one to two hours at a time each day for five to six

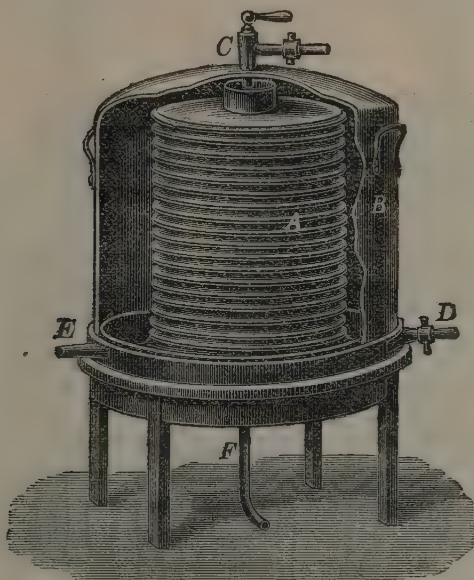


FIG. 74.—Milk cooler—by Schmidt, in Bretten.

days consecutively at 75° C., the destruction of spores, which in the meantime would have developed, can be accomplished. In practice, however, this process would be too expensive and too troublesome. A modification of this process consists in heating the milk in closed flasks to a high temperature (above the boiling point of water).

The thorough sterilization of milk is, therefore, not very practical, but one or two methods and apparatus may be described. In the Neuhauss-Gronwald-Oehlmann sterilization apparatus (fig. 75) the milk is heated first to 85° to 90° C., and then a second time to 102° C. The bottles must be well blown and annealed, free from alkali, and very carefully cleaned. This is accomplished by boiling with soda, then with water, and finally by sterilizing in large boxes at 100°. The bot-

tles are closed with a patent stopper, like the beer-bottle stoppers, and these must be carefully sterilized before use, using only those with the best rubber rings. After sterilization the flasks are carefully filled with the milk, the hands being first very thoroughly washed and all antiseptic precautions observed. The milk is then heated for half an hour at 85° to 90° C., and the flasks are gradually cooled, being allowed to remain in the sterilizer. They are on the same day submitted to a second heating of 102° to 103° C. The apparatus consists of a double-walled box, made of tinned copper plates. The lower portion, *a*, is fixed; the top, *b*, movable and counterbalanced by weights; the top fits over the lower basket steam tight; *c* is a thermometer, and *d* an escape steam

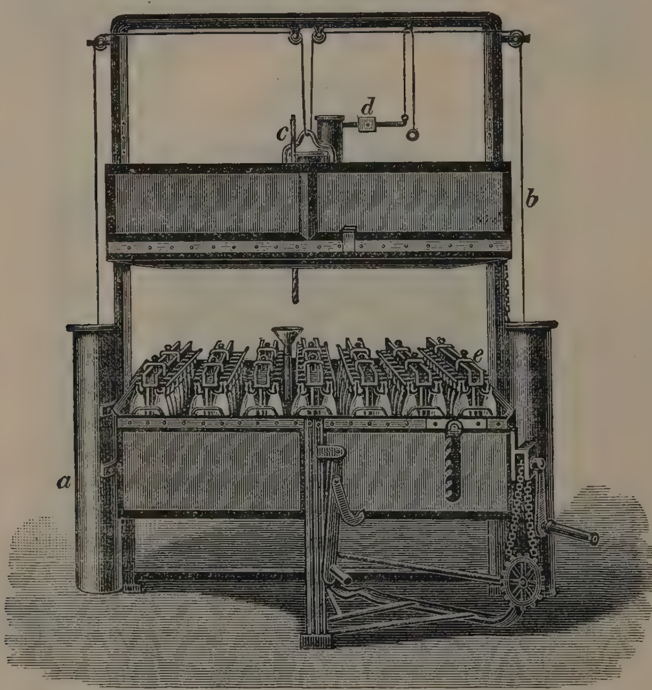


FIG. 75.—Sterilizing apparatus, by Neuhauss-Gronwald-Oehlmann.

valve which can be set at any desired pressure. The flasks are placed in special trays which can be easily moved, and between the rows of flasks are levers which serve to close the patent stoppers. The thermometer dips into one of the flasks and indicates the temperature of the milk. When the apparatus is closed, the steam, under pressure of 1½ atmospheres, is allowed to enter slowly until the air is driven out. It is important that the apparatus shall not be entirely closed until the air is entirely driven out. When the temperature has reached 100° C., more steam is turned on, the pressure gauge having been set for 102° to 103° C. In a short time the flasks will have reached a temperature of 100° C., and they are then kept at this temperature for thirty min-

utes. A few minutes before the end of the sterilization the pressure valve is opened, thus permitting the milk in the flasks to boil up, and any gases which might still be present in the milk are driven out. The result is that the closed flasks of milk, when cold, no longer contain any air, as in the upper part of the flask there is a vacuum, consequently aerobic bacteria could not multiply. The flasks are now allowed to cool slowly to 50° to 60° C., then placed in warm water to prevent cracking. Cold water is gradually allowed to mix with this, and the flasks are finally preserved on ice. The purer and fresher the condition of the milk, the more satisfactory are the results obtained. In this connection, if milk is to be used for thorough sterilization, special care should be taken to see that the milk is not unnecessarily exposed to contamination by such bacteria as are difficult to kill and are apt to get into the milk from dirt, old straw, and bedding. In addition, cans, bottles, and receptacles must all be kept perfectly clean.

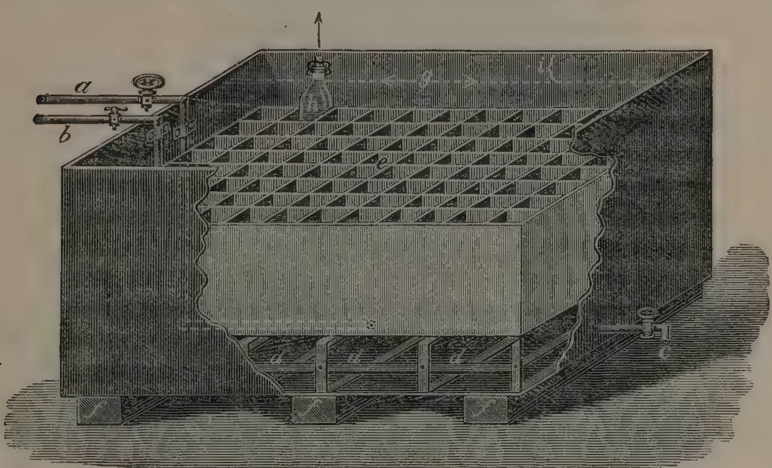


FIG. 76.—Milk-sterilizing apparatus—after Paul Ritter von Hamm.

In practice, it makes a difference whether the sterilization is conducted with heated water or with steam, whether the steam is mixed with air, is moist or dry. Although the process above described is usually satisfactory, yet a complete sterilization does not always result. It has been found, too, that almost equally satisfactory results are secured by heating to 102° to 103° C. for three-fourths to one hour, without any previous sterilization.

The Soxhlet apparatus, originally intended for household use in sterilizing milk, has been utilized, with slight modifications, for sterilizing the milk in quantity (fig. 76). This is intended for 94 flasks of 1 liter (1 quart) capacity, or, instead of the flasks, cans with patent air-tight covers may be used. The apparatus is simple in construction. *a* serves for the admission of steam, *b* for the admission of water, and *c* is the outlet tube. The bottle holder, *e*, is made of wood, and rests on metal bars. The holder is filled with water to *g*, and the flasks are filled with

milk to *h*, and placed in the box. The stoppers are the ordinary beer-bottle stoppers, and are loosely placed in the mouths of the bottles. Steam is then turned on until the temperature, shown by the thermometer that passes through the cover of the whole box, reaches 110°. This requires about one hour, and the flasks are kept at this temperature for fifteen minutes. The milk fills the bottles entirely and a little runs out from the mouths. When the steam is turned off and cold water is introduced to reduce the temperature of the flasks to 50° C., the contraction of the milk draws the corks down tightly on the bottles, and the wire clamp can then be readily fastened.

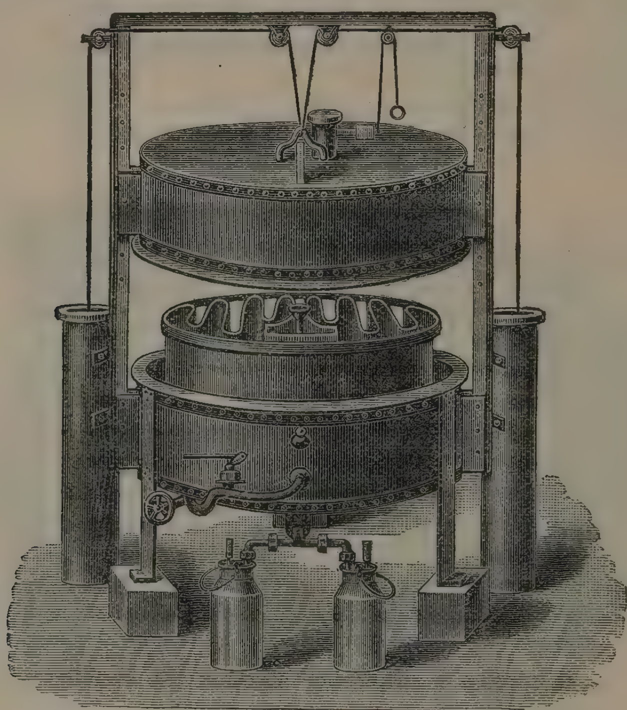
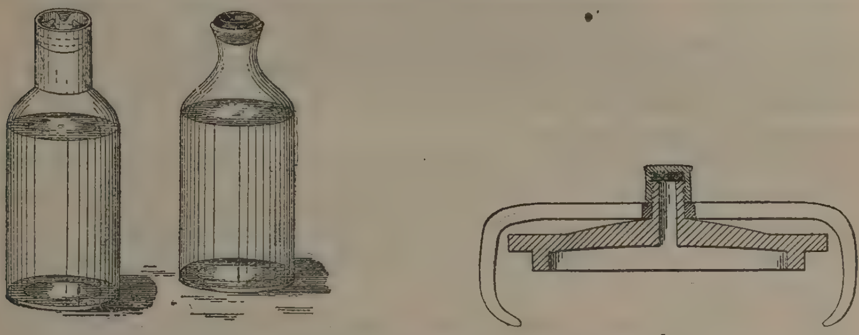


FIG. 77.—Bottling sterilizing apparatus.

A number of creameries have begun the process of shipping sterilized milk in cans of 10 to 12 liters capacity. An apparatus adapted to this purpose is shown in figure 77. The milk flows through a trough arranged in folds, so that a large surface is exposed to the action of the steam, and passes directly through sterile tubes into cans.

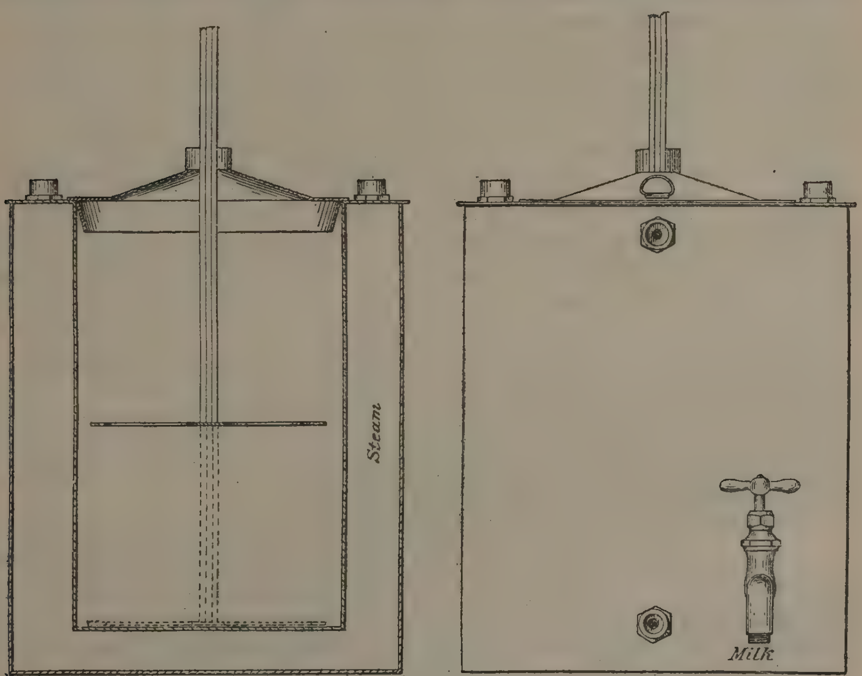
In addition to the sterilizing apparatus already described, the following (fig. 78, *b*) may be used: An ordinary fruit jar may have an opening cut through the top of the cover, provided with a shoulder and lid that will screw down. Through this opening an agitating rod or wire may be passed to keep the milk thoroughly stirred up while it is being heated. This can then be removed after heating, and the opening is then closed while the flask is still hot; or this opening may have a stiff cotton plug.

Another arrangement which will answer the purpose for sterilizing milk in quantity may also be used. A double-walled rectangular box, made of copper or tin (fig. 79), may be arranged so that the milk can be heated to any desired temperature. This can be stirred during the process and the milk at the same time sterilized. Any loss or change in the taste of the milk is detrimental when it is to be used for food. The thorough stirring of the mass keeps it evenly heated throughout, so



a. *b.*

FIG. 78.—*a*, Soxhlet's patent sterilizing bottles and top; *b*, top for fruit jar for sterilization.



Interior. *Exterior.*

FIG. 79.—Sterilizing box.

that there will be no charring or scorching of any milk or any adhering to the sides of the vessel. A series of these rectangular boxes might be provided, connected with each other by pipes and stopcocks. From these sterilizers the milk may be filled into sterilized bottles, or into

large sterile cans, which can be hermetically sealed. To save expense, the outside of this double-walled box might be made of wood, or, better, of sheet iron, and the whole then incased in a wooden box to retain the heat.

The flasks or other vessels in which the milk is stored should, after cooling to about 60° C., be placed in water and thoroughly cooled.

The proper cooling of the milk and placing in clean bottles or cans is absolutely necessary for securing the full effect and purposes of pasteurization or sterilization.

The methods and apparatus which have been described are all adapted for the pasteurization or sterilization of milk. While some will appear too complicated and expensive to be adopted or copied, others will be found well suited, or modifications and improvements will easily suggest themselves.

That a uniform and cleanly milk supply can be obtained only when the State or town undertakes official control and inspection of animals has already been indicated. Where this is lacking, the consumer and the public generally may protect themselves in a great measure from disease by adopting any of the methods above indicated, either in the household or in the creameries. For these processes to be successful, the utmost cleanliness of vessels and manipulation must be observed; the milk must be clean, well-strained and aerated, the pasteurization or sterilization systematically conducted, the milk filled into bottles and cans while hot, and these latter then cooled before distribution. The pasteurized or sterilized milk should be distributed in unbroken packages only, and these should be no larger than would be used in twenty-four hours. If distributed in large vessels, these should be hermetically sealed to avoid all contamination. Probably the cheapest vessel, and the one most easily obtained for sterilization in small lots, is the ordinary patent-stoppered beer bottle; for handling in larger quantities, milk cans with hermetically sealed tops.

The apparatus for continuous sterilization does not give as satisfactory results as when an interrupted process is adopted.

By the use of properly pasteurized or sterilized milk, therefore, not only should the spread of disease be lessened, but also the health of milk consumers in general should be improved.

The use of pasteurized or sterilized milk prepared in bulk can, however, only be carried out to the best advantage when it is undertaken with the object, not of making money by supplying a material which will barely pass inspection, but of furnishing an article collected and prepared with all possible precautions, where all means have been adopted to provide against mistakes or carelessness.

The simpler forms of apparatus described can be easily and cheaply manufactured by any good tinner or coppersmith, and many slight modifications and improvements will suggest themselves in practice.

FOOD AND DIET.

By W. O. Atwater, Ph. D.,

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"Half the struggle of life is a struggle for food."—*Edward Atkinson.*

"The labor question, concretely stated, means the struggle for a higher standard of living."—*Commissioner Carroll D. Wright.*

"I have come to the conclusion that more than half the disease which embitters the middle and latter part of life is due to avoidable errors in diet, * * * and that more mischief in the form of actual disease, of impaired vigor, and of shortened life accrues to civilized man * * * in England and throughout central Europe from erroneous habits of eating than from the habitual use of alcoholic drink, considerable as I know that evil to be."—*Sir Henry Thompson.*

"If we care for men's souls most effectively, we must care for their bodies also."—*Bishop R. S. Foster.*

What proportion of the cost of living might be saved by better economy of food; how far such economy would help the wage worker to the higher plane of living toward which he justly strives; how dietary errors compare in harmfulness with the use of alcohol; and to what extent the spread of the gospel and the perfection of its fruit are dependent upon the food supply—are questions hardly possible of exact solution in the light of our present knowledge. The foregoing statements are quoted, however, because they come with authority, and because, starting from the widely different standpoints of the economist, the statistician, the physician, and the divine, the conclusions tally perfectly with those to which the study of the chemistry and economy of food seems to lead.

With the progress of human knowledge and human experience we are at last coming to see that the human body needs the closest care. We are coming to realize that not merely our health, our strength, and our incomes, but our higher intellectual life, and even our morals, depend upon the care which we take of our bodies, and that among the things essential to health and wealth, to right thinking and right living, one, and that not the least important, is our diet.

The power of a man to do work depends upon his nutrition. A well-fed horse can draw a heavy load. With less food he does less work. A well-fed man has strength of muscle and of brain, while a poorly nourished man has not. A man's nourishment is not the only factor of his producing power, but it is an important one.

This subject concerns the laboring classes in many ways. Statistics as well as common observation bear emphatic testimony to the better condition of the American as compared with the European working-

man in respect to his supply of the necessaries and comforts of life. Nowhere is this superiority more striking than in the quality and quantity of his food. And the difference in the dietaries of the two is especially marked in the larger amount of potential energy, of capability to yield muscular strength for work and to fulfill other uses in nutrition, which characterizes the food of the American. That the American workman, in many cases at least, turns out more work per day or per year than his European competitor is a familiar fact. That this superiority is due to more nutritious food as well as to better use of machinery and to greater intelligence is hardly to be questioned. But the better nourishment of the American wage worker is largely due to our virgin soil. With the growth of population and the increasing closeness of home and international competition his own diet can not be kept up to its present nutritive standard, nor can that of his poorer neighbor and his foreign brother be brought up nearer to that standard, without better knowledge and application of the laws of food economy.

To the farmer also the subject is important. Materials for the food of man make up the larger part of our agricultural production and the largest item of our export abroad. Our food production is one-sided. It includes a relative excess of the fat of meat, of starch, and of sugar, the substances that serve the body for fuel to yield heat and muscular power, while the nitrogenous substances, those which make blood and muscle, bone and brain, are relatively deficient. This is unfortunate for the consumer, because it leads him to buy material which he does not need and makes his diet one-sided, and hence injurious to health and strength. It is unfortunate for the farmer also, because it decreases the value of his product; and the very things which are needed to make his food product more valuable are the ones which will make it cheaper to produce. What is needed is more nitrogen in the soil for plant food, more nitrogen in plants to make better food for animals and man, and more nitrogen in the food of man. Better culture of the soil and better manuring will bring not only larger crops, but crops richer in nitrogen. The cultivation of more clover, alfalfa, vetch, cowpeas, peas, beans, and other leguminous crops which obtain nitrogen from the air will help in the same direction. With more nitrogenous material in his crops the farmer can make more meat, and meat with less excess of fat, and at less cost; he can produce milk, butter, and cheese more profitably, and at the same time he can be improving his land. The food for man which he thus produces will be better adapted to the actual needs of the community, much of the prevalent waste of material will be avoided, and both producer and consumer will receive the benefit.

Most people pay very little attention to these matters. The result is great waste in the purchase and use of food, loss of money, and injury to health. The chief reason why people act as they do is found in a lack of information about food and nutrition, and in the widespread and

unfortunate prejudice against economy in diet. The remedy for the evil will come only with the spread of knowledge of the subject.

DEFINITION OF FOOD AND ECONOMY.

The following statements will help to make clear the fundamental principles of the subject:

(1) Food is that which, when taken into the body, builds up its tissues and keeps them in repair, or which is consumed in the body to yield energy in the form of heat to keep it warm and create strength for its work.

(2) The most healthful food is that which is best fitted to the wants of the user. To be adapted to his wants, the food must supply the different nutritive ingredients, or nutrients, in the kinds and amounts needed by the body to build up its several parts, to repair them as they are consumed by constant use, and to yield energy in the form of heat and muscular power. The ingredients should also be supplied in forms which the person can easily digest and which will "agree" with him. If the nutrients are not supplied in the right proportions, or if they are not in easily digestible forms, or if they yield material which does not agree with the user, injury to health and strength will result.

(3) The cheapest food is that which furnishes the most nutriment at the least cost.

(4) The most economical food is that which is both most healthful and cheapest.

THE ACTUAL NUTRIMENT OF FOOD AND ITS COST.

A picture in a magazine has just struck my eye. It is a family scene in a humble home. The four children are sitting at the table with bowls of milk before them, while the mother holds in her hand a loaf of bread which she is cutting into slices for their dinner. The room is neat, but plain; the furniture is of the simplest kind, and the children's clothes are of ordinary material, with here and there a well-sewed patch. The mother's air is that of a busy housewife, her thought one of tender care for her family, but there is a trace of anxiety in the lines of her face which is in contrast with the careless eagerness of her little ones. Doubtless the father has taken his dinner with him to his daily work, by which, if he be an average bread winner, with health and industry, he may earn $500 per year. If he is not addicted to drink, the whole of this sum will go for the support of his family. It must pay for food, clothing, fuel, rent, and doctor's bills, leaving not a very large remainder for the extra comforts of the home, an occasional new carpet or piece of furniture, books, or a short excursion in summer, with perhaps a little for a life insurance or the savings bank or a timely help for a less fortunate neighbor.

When the mother goes to the market to make her purchases, she is thinking of meat and flour and potatoes, what they cost, and how the folks at home will relish them. But in fact, though she does not realize

it, she is buying certain nutritive substances in the food—flesh formers and fuel ingredients, which she and her husband need to repair the wastes of their bodies and to give them strength for their daily toil, and which their children must have for healthy growth and work and play. Her real problem, though she does not understand it, is to get the most and the best nutriment for her money. She is accustomed to buy certain materials, but if, by wiser selection, she could get abundant nutriment at less cost, and thus save a little money for extra comforts for the family or to put by in the savings bank, it would be fortunate.

The members of the family need, as essential for the day's diet, certain amounts of protein to make blood and muscle, bone and brain, and corresponding quantities of fat, starch, sugar, and the like, to be consumed in their bodies, and thus to serve as fuel to keep them warm and to give them strength for work—a larger amount for the father, with his active muscular labor; somewhat less for the mother, with her smaller body and lighter work; and quantities for the children according to age, growth, and occupation. Of course they need other substances, like mineral salts, which are contained in the food, and the water of both food and drink, and they want and will have things like salt and spice and tea and coffee, which gratify the palate and are more or less useful for nourishment.

If this family live in a village or city in Massachusetts, about $300 of their annual $500 will be expended for food.[1] Will it be expended wisely?

Due regard for health, strength, and purse requires that food shall supply enough protein to build tissue and enough fats and carbohydrates for fuel, and that it shall not be needlessly expensive. The protein can be had in the lean of meat and fish, in eggs, in the casein (curd) of milk, in the gluten of flour, and in substances more or less like gluten in various forms of meal, potatoes, beans, peas, and the like.

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[1] The smaller the income, the larger is the proportion used for food, as is illustrated by the following figures, summarized from those of Hon. Carroll D. Wright in the report of the Massachusetts bureau of statistics for 1884:

Percentage of family income of workingmen in Massachusetts expended for subsistence.

Annual income.	Amount expended for food.	Per cent expended for food.
$350 to $400	$224 to $256	64
450 to 600	284 to 378	63
600 to 750	360 to 450	60
750 to 1,200	420 to 672	56
Above 1,200	612	51

In parts of the West and South, where food is very cheap, its cost in proportion to other expenses is less, and sometimes falls a little below half the income. In Europe, where incomes are smaller and food dearer, the cost of food makes a larger part of the whole expenditure.

These statements apply less accurately to farmers than to the inhabitants of the larger towns; but, although the farmer produces much of his food, yet, taking everything into account, the expense for nutriment is large even for him.

Fats are supplied in the fat of meat and fish, in lard, in the fat of milk, or in the butter made from it; it is also furnished, though in small amounts, in the oil of wheat, corn, potatoes, and other vegetable foods. Carbohydrates occur in great abundance in vegetable materials, as in the starch of grains and potatoes, and in sugar. The fats, sugars, and starches all serve for fuel, and we may measure their quantity by their fuel value, expressing this in heat units, or calories,[1] as they are commonly called. In the food this woman buys, then, she has to deal with protein, or tissue formers, and with fuel values.

If her husband is engaged at moderately hard muscular work, like that of a carpenter or mason or active day laborer, he should have in his day's food say 0.28 pound of protein and enough carbohydrates and fats so that the fuel value of the whole will be about 3,500 calories. The wife, if busy at work with her hands about the house or otherwise, will need perhaps eight-tenths as much. If the children are two boys of 13 and 8 and two girls of 10 and 5 years of age, they will need enough to make the wants of the whole family equivalent, let us say, to four men at moderately hard work. This would require 1.12 pounds of protein, and a fuel value of 14,000 calories. It could be supplied by various food mixtures—some dearer and some cheaper. If the costlier meats, oysters, or eggs at high prices are used, the diet will be an expensive one, but if the animal food is used in the forms of the less costly meats, in milk and cheese in not too large quantities, and if the bulk of the diet consists of such wholesome vegetable foods as wheat flour, corn meal, oatmeal, peas, beans, and potatoes when the last are not too dear, the cost will be very much less. Some specimens of food mixtures, with amounts of ingredients and costs, are given in the Appendix (Human Foods, Table D).

NUTRITIVE INGREDIENTS OF FOOD.

The real problem before this woman when she goes to market is to obtain, at the least cost, protein, fats, and carbohydrates needed to meet the wants of her family. Flavor and appearance are things to look out for, of course. She may buy them in the food if she has the money and is willing to spend it, but they are costly. She may supply them by good cooking and tasteful serving, but this will take skill and care, and too many women in her circumstances lack the one and are averse to the other. Or she may ignore both flavor and appearance, and if her husband does not like the food she sets before him, and other things about the home are not attractive, he will very likely go to the "poor man's club," otherwise known as the saloon.

The training of a well-ordered home or the cooking school will tell how to make savory dishes from inexpensive materials. A little of the chemistry of the subject will show how to select them.

Table A (Human Foods, Appendix) gives the composition of speci-

[1] A calorie is the amount of heat required to raise a pound of water 4° F.

mens of common food materials. The composition of a smaller number is shown in figure 80 herewith.

Thus a pound of sirloin of beef of medium fatness will furnish, say, 0.15 pound of protein in the "lean" and 0.16 pound of fat. The fuel value of the protein added to that of the fat makes 970 calories in the pound of sirloin. A pound of wheat flour of average quality will contain about 0.11 pound of protein, in the form of gluten; 0.01 pound of fat, which, if extracted from the flour, would be an oily substance; and 0.75 pound of carbohydrates, of which nearly all would be starch. The fuel value of these nutrients in the pound of flour would be, according to Table A, 1,645 calories.[1]

Food materials rich in protein are the most valuable for building the tissues of the body. A pound of cheese may have 0.28 pound of protein, as much as a man at ordinary work needs for a day's sustenance, while a pound of milk would have only 0.04 and a pound of potatoes only 0.02 pound of protein. The materials which have the most of fats and carbohydrates have the highest fuel value. The fuel value of a pound of fat pork may reach 2,995 calories, while that of a pound of salt codfish would be only 315 calories. On the other hand, the nutritive material of the codfish will consist almost entirely of protein, of which the salt pork has very little.

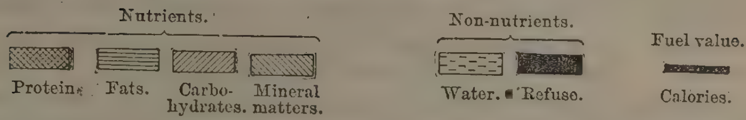
In general, the animal foods have the most of protein and fats, while the vegetable foods are rich in the carbohydrates, starch, and sugar. The lean meats and fish abound in protein. Cheese has so large a quantity of protein because it contains the casein of the milk. Among the vegetable foods, beans and peas have a high proportion of protein. The proportion in oatmeal is also large. In wheat it is moderate, and in corn meal it is rather small. The materials with the highest fuel value are those with the most fat, because the fuel value of the fat is, weight for weight, two and one-fourth times as great as that of either sugar, starch, or protein. Hence fat pork and butter lead the other materials in fuel value. The fat meats in general stand high in this respect. So also do the grains, flour, and meal, as they have large quantities of carbohydrates. Potatoes are quite low in the list in respect to fuel value as well as protein, principally because they are three-fourths water. For the same reason, milk, which is seven-eighths water, ranks low in respect to both protein and fuel value.

It is important to remember that all these estimates apply to the food materials in the form in which we buy them, including both refuse, like the bones of meat, skins of potatoes, etc., and water. If we were to remove the bones and other refuse from the meats, fish, and other foods which contain them, and then remove the water from all the materials, and compare the actually nutritive substances of nutrients, their rank would, of course, be very different. Salt codfish, for instance,

[1] Detailed explanations of the composition of food materials, the ways they are used in the body, and their nutritive values as compared with their cost, are given in Farmers' Bulletin No. 23 of the United States Department of Agriculture.

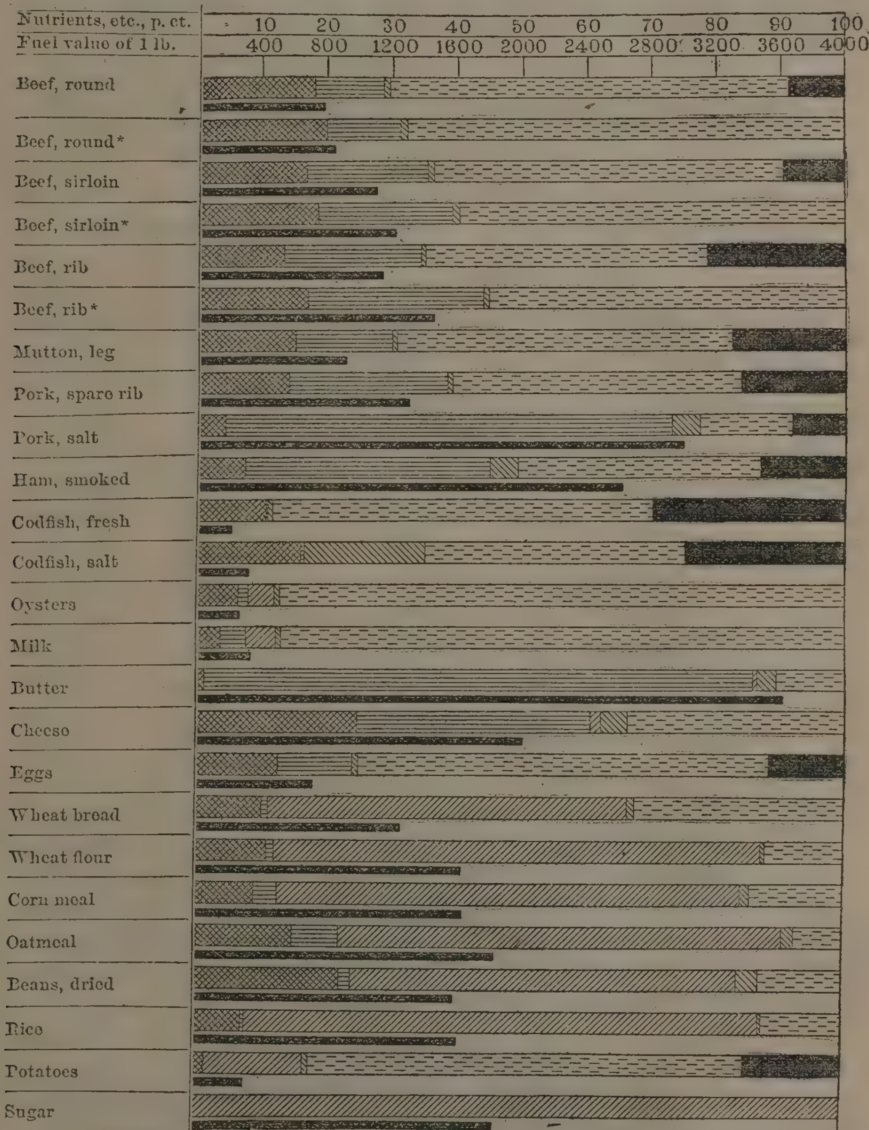
FIG. 80.—COMPOSITION OF FOOD MATERIALS.

Nutritive ingredients, refuse, and fuel value.



Protein compounds, e. g., lean of meat, white of egg, casein (curd) of milk, and gluten of wheat, make muscle, blood, bone, etc.

Fats, e. g., fat of meat, butter, and oil, } serve as fuel to yield heat and muscular power.
Carbohydrates, e. g., starch and sugar, }



* Without bone.

is a very economical food, because it furnishes protein in an easily digestible form, although, as we buy it, a pound will contain over eight-tenths of a pound of water and refuse. A pound of rice consists of about seven-eighths of a pound, and a pound of potatoes only one-fourth of a pound of nutritive materials, but in cooking the rice we mix water with it and thus make it not very different in composition from potatoes. By drying the potatoes we could get a material very similar in food value to rice.

In Table 1 a number of the most common articles of food are grouped according to their quantities of protein and their fuel values.

TABLE 1.—*Classification of food materials by composition.*

GRADATION BY AMOUNTS OF PROTEIN IN 1 POUND.	GRADATION BY FUEL VALUES IN 1 POUND.
VERY LARGE.	
.32 to .21 pound protein.	*4,220 to 1,700 calories.*
Canned corned beef; cheese. Beans, dry.	Butter; salt pork; cheese; smoked ham. Milk crackers; sugar; oatmeal.
LARGE.	
.20 to .16 pound protein.	*1,700 to 1,200 calories.*
Canned salmon; beef, round; beef, sirloin; salt codfish; beef, chuck.	Pork, spare rib. Corn (maize) meal; wheat flour; rice; beans, dry; wheat bread.
MEDIUM.	
.15 to .11 pound protein.	*1,200 to 700 calories.*
Mutton, leg; pork, spare rib; beef, rib; eggs; fresh codfish. Oatmeal; wheat flour.	Canned corned beef; beef, rib; beef, sirloin; canned salmon; beef, chuck; mutton, leg; beef, round; eggs.
SMALL.	
.10 to .06 pound protein.	*700 to 300 calories.*
Smoked ham. Wheat bread; milk crackers; corn (maize) meal; rice.	Milk; salt codfish. Potatoes.
VERY SMALL.	
.05 pound and less protein.	*300 calories and less.*
Oysters; salt pork; milk; butter. Potatoes; sugar.	Oysters; fresh codfish.

Before leaving the subject of the composition of food materials, a word of caution is in order. The figures in Table A in the Appendix represent the averages of the analyses now available. But different specimens of the same kind of food materials may vary widely in composition. This is especially true of meats, because of the variations in the proportions of bone and of fat.

CHEAP AND DEAR FOODS.

To get at the actual cheapness or dearness of different food materials we must take into account both the composition and the price. Suppose, for instance, our would-be thrifty housewife, in buying food at the

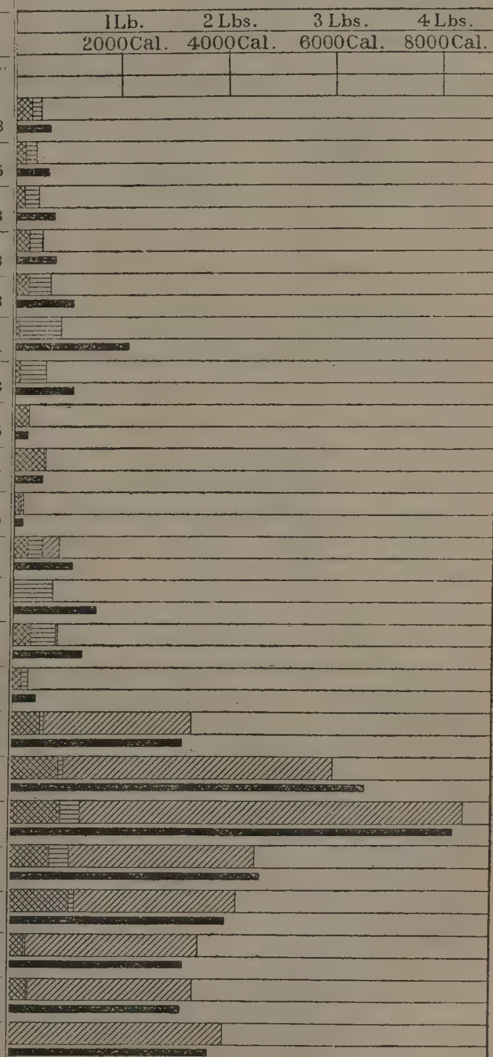
FIG. 81.—PECUNIARY ECONOMY OF FOOD.

Amounts of actually nutritive ingredients obtained in different food materials for 10 cents.

Protein. Fats. Carbohydrates. Fuel value.

Protein compounds, e. g., lean of meat, white of egg, casein (curd) of milk, and gluten of wheat, make muscle, blood, bone, etc.
Fats, e. g., fat of meat, butter, and oil, } serve as fuel to yield heat and muscular power.
Carbohydrates, e. g., starch and sugar, }

	Price per pound.	Ten cents will buy—	Pounds of nutrients and calories of fuel value in 10 cents' worth.
	Cents.	*Lbs.*	
Beef, round	12	.83	
Beef, sirloin	18	.55	
Beef, rib	16	.63	
Mutton, leg	12	.83	
Pork, spare rib	12	.83	
Pork, salt, fat	14	.71	
Ham, smoked	16	.63	
Codfish, fresh	8	1.25	
Codfish, salt	6	1.67	
Oysters, 40 cents quart	20	.50	
Milk, 6 cents quart	3	3.33	
Butter	24	.42	
Cheese	16	.63	
Eggs, 25 cents dozen	16⅔	.60	
Wheat bread	4	2.50	
Wheat flour	2½	4.00	
Corn meal	2	5.00	
Oat meal	4	2.50	
Beans, white, dried	4	2.50	
Rice	5	2.00	
Potatoes, 60 cents bushel	1	10.00	
Sugar	5	2.00	



market for her family, wishes to obtain the largest amount of nutriment for her money. What kind shall she select? To put it in another way, How much of tissue formers and fuel value can she obtain for a given sum—10 cents, for instance—in beefsteak, flour, or potatoes, as she ordinarily buys them?

If she spends her dime for beefsteak at 20 cents a pound, she gets half a pound, which supplies 0.08 pound of protein and 550 calories of energy; but if she invests the same money in flour at 2½ cents a pound, she has 4 pounds, with 0.44 pound of protein and 5,680 calories of energy. Table B (Human Foods, Appendix) shows the quantities of nutrients and energy in 10 cents' worth of each of a number of food materials at ordinary prices. Figure 81 illustrates the differences, and Table 2 herewith shows the gradation of a small number:

TABLE 2.—*Classification of food materials by cost of actual nutriment; i. e., by amounts of protein and energy in the quantities bought for 10 cents at ordinary prices per pound.*

GRADATION BY AMOUNTS OF PROTEIN IN 10 CENTS' WORTH AT PRICES STATED PER POUND.	GRADATION BY FUEL VALUES OF 10 CENTS' WORTH AT PRICES STATED PER POUND.
VERY CHEAP.	
.75 to .26 pound protein.	*9,000 to 3,000 calories.*
Salt codfish, 6 cents. Beans, dry, 4 cents; wheat flour, 2½ cents; oatmeal, 4 cents; corn meal, 2 cents; wheat bread, 4 cents.	Wheat flour, 2½ cents; corn meal, 2 cents; oat meal, 4 cents; beans, dry, 4 cents; sugar, 5 cents; rice, 5 cents; potatoes (60 cents bushel), 1 cent; wheat bread, 4 cents.
CHEAP.	
.25 to .18 pound protein.	*3,000 to 1,800 calories.*
Canned corned beef, 12 cents; milk (4 cents quart), 2 cents; skim milk (3 cents quart), 1½ cents. Potatoes (60 cents bushel), 1 cent.	Salt pork, 12 cents. Milk crackers, 9 cents; wheat bread, 6 cents.
MEDIUM.	
.17 to .13 pound protein.	*1,800 to 1,000 calories.*
Cheese, 16 cents; beef, chuck, 12 cents; beef, round, 12 cents; fresh codfish, 8 cents. Wheat bread, 6 cents; rice, 5 cents.	Butter, 24 cents; cheese, 16 cents; smoked ham, 16 cents; pork, spare rib, 12 cents; skim milk (3 cents quart), 1½ cents; milk (4 or 6 cents quart), 2 or 3 cents.
EXPENSIVE.	
.12 to .08 pound protein.	*1,000 to 500 calories.*
Mutton, leg, 12 cents; pork, spare rib, 12 cents; milk (6 cents quart), 3 cents. Milk crackers, 9 cents.	Canned corned beef, 12 cents; beef, chuck, 12 cents; mutton, leg, 12 cents; beef, rib, 16 cents; beef, round, 12 cents; beef, sirloin, 18 cents; salt codfish, 6 cents.
VERY EXPENSIVE.	
.07 pound and less protein.	*500 calories and less.*
Smoked ham, 16 cents; salt pork, 12 cents; oysters, 30 cents quart.	Fresh codfish, 8 cents; oysters, 30 cents quart.

The most striking fact brought out by all these calculations is the difference between the animal and vegetable foods in the actual cost of nutriment. Meats, fish, poultry, and the like are expensive, while flour and potatoes are cheap food. The reason of this is simple. The animal foods are made from vegetable products. Making meat from grass or grain is costly. An acre of land will produce a given number of bushels of wheat, but when the grass or grain which the same land would produce is converted into meat it makes much less food than the wheat.

DIGESTIBILITY OF FOOD.

These calculations do not take into account the digestibility of the food. In general, the animal foods are somewhat more digestible than the vegetable foods. The protein of ordinary meats, for instance, is practically all digested when it is eaten in moderate quantities by healthy persons, but the same persons might digest only nine-tenths of the protein of wheat flour made into bread, and not more than three-fourths of that of potatoes. The fat of meats is less completely digested. The sugar and starch of vegetable foods, properly cooked, is very easily and completely digested.[1]

THE FITTING OF FOODS TO THE NEEDS OF THE BODY.

Different people have different needs for nutriment. All are alike in that they must have protein for the building and repair of the bodily machine, and fuel ingredients for warmth and work. But they differ widely in the amounts and proportions they require, and even among those in good health there are many who are obliged to avoid certain kinds of food, while invalids and people with weak digestion must often have special diet.

For people in good health and with good digestion there are two important rules to be observed in the regulation of the diet. The first is to choose the things which "agree" with them, and to avoid those which they can not digest and assimilate without harm. The second is to use such kinds and amounts of food as will supply all the nutrients the body needs and at the same time avoid burdening it with superfluous material to be disposed of at the cost of health and strength.

For guidance in this selection, nature provides us with instinct, taste, and experience. Physiological chemistry adds to these the knowledge—still new and far from adequate—of the composition of food and the

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[1] Detailed statements of the results of experiments upon the digestibility of food by man and the effects of cooking upon digestibility may be found in Bulletin No. 21 of the Office of Experiment Stations of this Department on the Chemistry and Economy of Food. Brief explanations regarding the digestibility of food are given in Farmers' Bulletin No. 23 of the same Department.

laws of nutrition. In our actual practice of eating we are apt to be influenced too much by taste, that is, by the dictates of the palate; we are prone to let natural instinct be overruled by acquired appetite; and we neglect the teachings of experience. We need to observe our diet and its effects more carefully, and regulate appetite by reason. In doing this we may be greatly aided by the knowledge of what our food contains and how it serves its purpose in nutrition.

What kinds of food best agree with any individual is a matter to be found out by experience. Milk is for most people a very wholesome, digestible, and nutritious food, but there are persons who are made ill by drinking it; they should avoid milk. The author knows a boy who is made seriously ill by eating eggs. A small piece of sweet cake in which eggs have been used will cause him serious trouble. The sickness is nature's evidence that eggs are, for him, an unfit article of food Some people have to avoid strawberries. Indeed, cases in which the most wholesome kinds of food are hurtful to individual persons are, unfortunately, numerous.

How it is that food which contains nothing unwholesome can be so harmful has always been a mystery until, within a few years past, chemistry has begun to explain the changes that food undergoes in the body. It appears that in their course through the body the constituents of the food are subject to a great variety of chemical changes, and that some of the compounds formed may be at times harmful in one way or another. Some of the compounds produced from the food in the body may be actually poisonous. Different persons are differently constituted with respect to the chemical changes which their food undergoes and the effects produced, so that it may be literally true that "One man's meat is another man's poison." Every man must learn from his own experience what food agrees with him and what does not.

On the other hand, some foods have at times a great value outside of their use for nourishment. Fruits and garden vegetables often benefit people greatly, not as nutriment merely, for they may have very little of actual nutrients, but because of the vegetable acids or other substances which they contain, and which sometimes serve a most useful purpose.

Food does more than to build tissue and yield energy. What it does in other ways—its value as medicine rather than nutriment—this is not the place to discuss. Let us return, then, to our subject, which is food economy.

For the great majority of people in good health the ordinary food materials—meats, fish, eggs, milk, butter, cheese, sugar, flour, meal, potatoes, and vegetables—make a fitting diet, and the main question is to use them in the kinds and proportions fitted to the actual needs of the body. This will be best answered by considering the subjects of dietaries and dietary standards.

STANDARDS FOR DAILY DIETARIES.

Various attempts have been made by physiologists and chemists to devise standards to represent the amounts of nutrients needed by people of different age, sex, and occupation for their daily sustenance. There are two great difficulties in the way of setting up such standards. The first is that we have not yet enough definite knowledge to say exactly how much nutriment the average man or woman who does a given kind and amount of work actually needs to keep his or her body in good condition, to make blood and muscle and other tissues as they are constantly used up, and to serve as fuel to keep the body warm and supply it with strength for work. Nor can we yet say just how much an average child of a given age and period of growth requires to build up its growing body, repair the wastes, and give it warmth and strength for its work or play.

The other difficulty in the way of laying down hard and fast rules to regulate the diet is that different individuals of the same class differ so widely in their demands for food and in the use they make of it. Two men of like age, size, build, and occupation may live and work side by side. One will eat more and the other less, while both do the same amount of work; or both may eat the same food and do the same work, and one will be fat and the other lean; or both may have the same diet, and yet one will be strong and vigorous and able to do a great deal of work, while the other will be weak and able to accomplish but little. Just why individuals differ in their ways of utilizing their food, and how to measure the differences and make dietary rules to fit them exactly, are problems which the physiological chemist of to-day is far from solving. The fact is that the whole subject is new, and the accurate investigation thus far made, though quite considerable when we get it all together, is far too small for satisfactory conclusions. The best we can do with our present knowledge, or rather lack of knowledge, of the subject is to make general estimates, with the clear understanding that they are only rough estimates, and that they apply to average rather than individual cases. For that matter, we can never expect to reduce this matter of diet to an exact science. The nutrition of man is not a mere matter of pounds of protein and units of energy. Even when the complex laws of our physical being are learned, if science shall reveal them to us in all their fullness, as we can hardly expect that it ever will, there will still remain factors outside the domain of chemistry and physiology, factors for which no physical measure is now or ever can be possible.

The ordinarily accepted standards for dietaries are estimated in terms of "protein," "fats," and "carbohydrates." The amounts of these appropriate for daily food for different classes of people under different conditions have been estimated in two ways:

(1) By observing the amounts actually consumed by individuals, and by groups of people differing in age, sex, occupation, and other conditions of life.

(2) By experiments in which the income and outgo of the body are directly compared. Experiments of this sort are made by supplying individuals with food of known amount and composition, and determining the quantity and composition of the products given off from the body. The most valuable researches thus far have been made with the so-called respiration apparatus. In these, the food, drink, and inhaled air, which make up the income and outgo of the body, are measured, weighed, and analyzed. The balance of income and expenditure is thus made, and the gain or loss of material of the body, with different kinds and amounts of food, and under different conditions of muscular exercise and rest, is determined.

The experiments involve a large amount of labor, but bring correspondingly complete and reliable results. They are of fundamental importance in learning the ways in which food is used in the body, and it is for this purpose that most of the respiration experiments have been made. The larger part of this kind of experimenting has been with domestic animals; only few trials have been made with men.

An improvement upon this method is now being attempted by several investigators. It consists in taking into account the income and outgo of energy along with the income and outgo of matter. The income of energy is measured by the potential energy of the food; the outgo is measured by the heat given off from the body and the muscular work done. The apparatus used may be called the respiration calorimeter. Experimenting with it is even more complex, laborious, and costly than with the respiration apparatus, so that while investigators have come to see its necessity, extremely few have attempted it,[1] and the research attempted by them is still in its beginning. Enough has been accomplished to show that the work is feasible and the time is ripe for extended and thorough experiments with men of different ages, bodily conditions, and callings.

Our best information regarding dietary standards comes from Germany, where studies have been made by numerous investigators, such as Liebig, and especially Voit and his followers of the Munich school of physiologists. The names of Payen in France, Playfair in England, and Moleschott in Italy deserve especial mention as contributors to our knowledge on the subject. It is a noteworthy fact, however, that very

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[1]Research of this especial kind has been undertaken by Professors Rubner and Rosenthal in Germany, Chauveau in France, and Burdon-Sanderson and associates in England, and in the writer's laboratory in Middletown, Conn. The only results thus far published, in which the income and outgo of energy have been measured, are those of a limited number of experiments by Rubner with dogs.

A more detailed, though not complete, discussion of the whole subject, including dietaries and dietary standards, is given in the bulletin on the Chemistry and Economy of Food, mentioned above.

little attention appears to have been paid in either the United States or England to the results of the latest and best research in this direction. Even the text-books in chemistry and physiology in the English language, which are looked upon as most authoritative, are too apt to pass the subject over most superficially or ignore it.

DIETARY STANDARDS FOR MEN AT MUSCULAR WORK.

Let us take, for instance, the case of an average "working" man—say a carpenter, blacksmith, or day laborer—who is doing a moderate amount of muscular work. To make up for the constant wear and tear of muscle, tendon, and other nitrogenous tissue, he must have protein. To use his muscles, strength or muscular energy is required. Furthermore, his body must be kept warm. The most of the energy is supplied by the fats and carbohydrates, but some come from protein. Our workingman, then, needs in his daily food (1) enough of protein to make up for the protein of muscle and other nitrogenous tissue consumed in his body; (2) enough energy to supply the demand for heat and muscular work.

The problem, then, is this: How much protein, fats, and carbohydrates does the average man, with a moderate amount of manual work to do, require in a day's food?

A number of noted European investigators have made diligent comparisons of the results of their own and other inquiries, and have set up certain standards, which are given in Table E, Human Foods, Appendix. In Table F are some standards proposed by the author after consideration not only of the data which were at the disposal of the authorities named above, but also of later ones, especially those obtained from the studies of American dietaries. For Americans at moderately active or at hard muscular work a more liberal allowance of nutrients has been provided than is given by any of the European authorities, for the reason, explained in more detail beyond, that people in this country work harder and need ampler nourishment than is common among wage workers in Europe.

Standards for daily diet of laboring man at moderate muscular work.

Author.	Nutrients in daily food.			
	Protein.	Fats.	Carbohydrates.	Fuel value.
	Pound.	*Pound.*	*Pounds.*	*Calories.*
Playfair, England	0.26	0.11	1.17	3,140
Moleschott, Italy	.29	.09	1.21	3,160
Wolff, Germany	.28	.08	1.19	3,030
Voit, Germany	.26	.12	1.10	3,055
Atwater, United States	.28	.17—.33	.83—1.21	3,500

No. 4 of the table, by Professor Voit, of the University of Munich, is the one most commonly quoted. It is intended to represent the needs of ordinary mechanics and laboring men at their usual work.

It was estimated from the food consumed by such men in Germany, and especially in the region of Munich, Bavaria. Voit would have somewhat over half of the 0.26 pound of protein of the food of the average laboring man at moderate work supplied by meat and other animal foods.

It will be borne in mind that these quantities, like those in the other tables of this article, generally refer to the total rather than the digestible nutrients of the food. Such dietaries as those proposed by Voit and the author would contain approximately the following amounts of digestible nutrients:

	Protein.	Fats.	Carbohydrates.
	Pound.	*Pound.*	*Pound.*
For laboring man at moderate work, Voit	0.25	0.11	1.00
For laboring man at moderate work, Atwater	.30	.21	.88

Of course, such standards as these represent only general averages. Thus Voit, Playfair, and the other physiologists named assume that for an ordinary laboring man, doing an ordinary amount of work, the amounts of nutrients stated in the table will suffice; that with them he will hold his own, and that any considerable excess above these quantities will be superfluous.

No one expects any given man to adjust his diet exactly to either of these standards. He may need more, and may perhaps get on with less. He may eat more fats and less carbohydrates, or he may consume more protein, if he is willing to pay for it. If he has much less protein and keeps up his muscular exertion, he will be apt, sooner or later, to suffer. But he may increase the fats and diminish the carbohydrates, or vice versa, within reasonable limits, without harm, because they both do the same work in the body and one may take the place of the other.

Different individuals, under like conditions, will both require and consume different quantities of nutrients. In general, the larger the person—that is to say, the bulkier the machinery in his organism—the more of protein and other nutrients will be consumed. Hence, men need, on the average, more than women.

The requirements vary with the muscular activity. A man at hard work requires more nutrients to make up for the wear and tear of the bodily machine and supply it with fuel than one at lighter work or at rest. Aged people, who are generally less active than those in the prime of life, require less food.

THE FOOD OF PEOPLE IN BUSINESS AND PROFESSIONAL LIFE.

Just what ingredients of the food serve for nourishment of the brain and nerves, and how they do that service, are mysteries which the physiological chemist has not yet solved. Brain and nerve contain the elements nitrogen and phosphorus, which occur in the protein com-

pounds, but are not found in the true fats or in the sugars and starches, which contain only carbon, hydrogen, and oxygen. A natural inference is that the protein compounds of the food and certain other substances in food, like lecithin, which also contain nitrogen and phosphorus, must be especially concerned in building up brain and nerve and keeping them in repair. This is practically as far as our present knowledge goes.

Just how much food the brain worker needs is a question for which the answer to-day is no more definite. In general, it appears that the man or woman whose occupation is what we call sedentary, who is without vigorous physical exercise and does but little of hard muscular work, needs much less than the man at hard manual labor, and that especially the brain worker needs comparatively little of carbohydrates and fats.

Many physicians, physiologists, and students of hygiene have the very firm conviction that well-to-do people, whose work is mental rather than physical, eat too much; that the diet of people of this class as a whole is one-sided as well as excessive, and that the principal evil is in the use of too much fat, starch, and sugar.

The facts of accurate experiment and observation upon this point are meager, but, such as they are, they tend to confirm this view very emphatically. Let us briefly consider some facts drawn from a review of all the reliable studies of the food of men in professional life which have been reported in the literature of the subject to which the author has had access. They include dietaries of 2 university professors, 3 lawyers, 3 physicians, and 5 medical students in Hesse-Nassau, Bavaria, Denmark, and Sweden—in all, 8 dietaries of 14 persons in Europe—and those of 1 retired merchant, 3 chemists, 2 college professors, and 4 boarding clubs of students in a college and in a theological school—in all, 10 dietaries of nearly 130 persons in Connecticut. The college students were mostly from a considerable number of Northern and Eastern States. Figure 82 shows the quantities of nutrients and energy in a number of these dietaries as compared with the dietary standards.

We may notice first some of the details of the European dietaries. Those of the two professors, one in the University of Marburg and the other in that of Munich, were studied by the gentlemen themselves with especial care. There was no restriction upon their diet; the attempt was to find how much food sufficed for the actual demand. Both were men of good health, vigorous, and in the prime of life. They had in their daily food, respectively, 0.20 pound and 0.22 pound of protein and 2,565 and 2,325 calories of energy. The three lawyers and two of the physicians lived in Munich, and were selected by Professor Forster, who made the studies, as individuals typical of their class. They were young, vigorous, well-to-do, and well nourished. The lawyers averaged 0.18 pound of protein and 2,400 calories; the physicians, who very

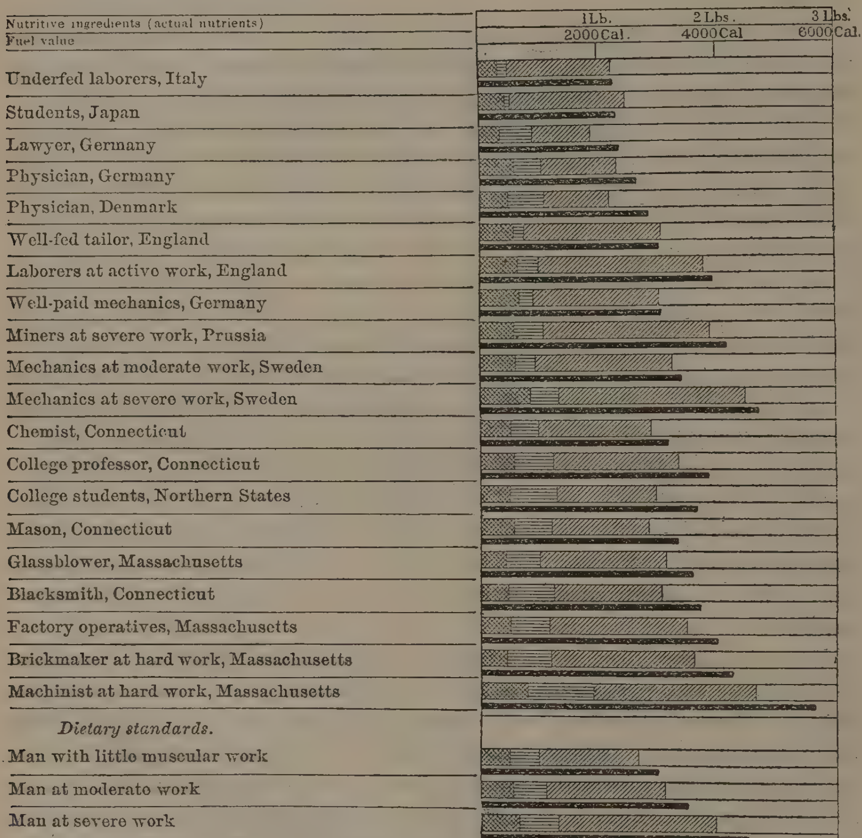
likely had more exercise, 0.28 pound of protein and 2,765 calories. The third physician, who lived in Copenhagen, had 0.30 pound of protein and 2,800 calories per day. The students were in Stockholm. They worked several hours per day in the laboratory, so that their occupation partook somewhat of the character of that of mechanics with

FIG. 82.—DIETARIES AND DIETARY STANDARDS.

Quantities of nutrients and energy in food per man per day.

Protein. Fats. Carbohydrates. Fuel value.

Protein compounds, e. g., lean of meat, white of egg, casein (curd) of milk, and gluten of wheat make muscle, blood, bone, etc.
Fats, e. g., fat of meat, butter, and oil, } serve as fuel to yield heat and muscular power.
Carbohydrates, e. g., starch and sugar,



light muscular work. They averaged 0.28 pound of protein and 3,035 calories of energy.

The order of the dietaries in respect to amounts eaten is interesting. Of the men engaged in professional duties, the professors and the lawyers, who would be presumed to have the least muscular exercise, con-

sumed the least food. The physicians, who, in the daily practice of their profession, would be expected to have more exercise, consumed more food. The people in Munich consumed the least, and those in the more northerly and colder latitudes of Denmark and Sweden the most. With the less muscular exercise and the warmer climate was the smaller, and with the more muscular activity and the colder climate was the larger, food consumption. This coincidence may be accidental, but it is worth noticing.

The important fact for our present purpose is this: Here are a considerable number of men in comfortable circumstances, able to provide themselves with ample food, and living in circumstances which would seem to favor proper nutrition. Their labor is mainly intellectual and their muscular work light. Their food contains from 0.18 to 0.30 pound of protein, and from 2,325 to 3,035 calories of energy per day. The average is 0.23 pound of protein and 2,670 calories of energy. For the active study or professional practice in which they are engaged, their nutriment is ample.

Let us now compare with these the dietaries of the professional men and students in Connecticut. As the waste may have been larger here than in the European dietaries, and we do not wish to exaggerate the difference between the two, we will compare the food actually eaten by the people in Connecticut with the total food supplied to the Europeans. In the 5 dietaries of as many families in Connecticut, 1 of a retired merchant, 3 of college professors, and 1 of a chemist, the protein ranged from 0.20 to 0.26 pound and averaged 0.24 pound, while the energy ranged from 3,205 to 4,080, and averaged 3,560 calories. Compared with the dietaries of the professional men in Germany and Denmark, those in Connecticut had a very little more protein and nearly one-half more fuel value.

The majority of the students in the Connecticut college were from the New England and Middle States. The same was true of those in the theological school, who were nearly all college graduates, a little older and somewhat less given to athletic sports and other kinds of physical exercise. Each of the clubs in which they boarded was managed by one of the number, who selected the food to suit their taste. It seems fair to assume that their eating habits were such as they had acquired at home; that, in other words, they represented the class of people in New England and the Middle States whose sons go to college. In the dietaries of these 115 young men the protein ranged from 0.20 to 0.31 pound and the energy from 3,085 to 4,825 calories. The average for protein was 0.26 pound, and that for fuel value, 3,720 calories. Of the Swedish students, there were only 5 dietaries of 5 individuals. These averaged 0.28 pound of protein and 3,035 calories. The number of persons for the comparison with the American students is small. The difference is less, but in general character it is the same as in the cases of the men in professional practice.

Did the professor and chemists in Connecticut require so much nutriment, when professors and physicians in Germany and Denmark are well nourished with so much less? Did the American students need food with so much more fuel value than the Swedish students? It seems to me very decidedly not.

The lower nutritive standard of the European as compared with the American wage worker coincides with his smaller income, which forbids generous diet, and his smaller capacity for work. But these European professional men and students were able to eat all they needed, and it might be difficult to prove that the intellectual activity of the American men of like calling was so much greater as to call for so great an excess of protein and fuel value in their food.

Doubtless, we live and work more intensely than people do in Europe. We also take more outdoor exercise. Students with us are, fortunately, much more given to athletic exercise than are German students. Possibly the medical students in Stockholm may have been so much more active physically than the young physicians in Munich and the other professional men in Germany as to need the ampler diet which they enjoyed. And it may very well be that the gentlemen in Connecticut used their muscles more and lived at higher tension than those on the other side of the Atlantic, and on these accounts needed more nutriment. But it is hard to see how they could have required food with a 50 per cent higher fuel value.

DIETARIES OF LABORING PEOPLE—FOOD, WORK, AND WAGES IN THE UNITED STATES AND IN EUROPE.

In 21 dietaries of mechanics, carpenters, cabinetmakers, coopers, locksmiths, shoemakers, farm laborers, and other wage workers in Germany, mostly in Bavaria, all of whom were counted as well-to-do for people of their class and were engaged in moderately hard work, the smallest quantity of food per man per day had a fuel value of 1,405 calories, and the largest 5,285, the average being 3,135. In 20 dietaries of factory and mill operatives, mechanics, and other laboring people in Massachusetts and Connecticut, who were also engaged in ordinary work, the smallest dietary furnished 3,055, the largest 5,340, and the average just about 4,000 calories. The people in New England whose food consumption is thus summarized included a very large percentage of factory operatives, whose standard of living was low as compared with that of the wage workers of the region generally, and yet their food was nearly one-third more nutritious than that of the better class of wage workers at ordinarily hard work in Germany.

In 11 dietaries of iron and steel workers, miners, brickmakers, and other wage workers in Prussia and Bavaria, who were counted as doing "hard" and "severe" work, the smallest furnished 3,365, the largest 5,690, and the average 4,390 calories per man per day. In 6 dietaries of machinists, blacksmiths, brickmakers, and others in Massachusetts

and Connecticut, also counted as doing "hard" and "severe" muscular work, the smallest furnished 4,250, the largest 7,805, and the average 5,710 calories. Here, again, the wage workers in Massachusetts and Connecticut were better nourished by one-third than those in Bavaria and Prussia.

In 40 dietaries of the people of the poorer classes in Prussia and Saxony the fuel value averaged 2,566 calories. The food of 25 families in the poorest part of Philadelphia averaged 3,235, and that of 36 families in the poorest part of Chicago, 3,425 calories. The poor people in the two American cities were better nourished by half than those referred to in Leipsic, Munich, and elsewhere in Germany.

The inhabitants of Saxony and Bavaria rank well among the population of Europe in respect to industry and thrift. Those whose food consumption is here reported were selected by investigators there as typical for their respective classes. Among the people whose dietaries were studied in Massachusetts and Connecticut were many (those in Philadelphia and Chicago were chiefly, foreigners whose standard of living and food consumption we should hardly expect to be up to the level of those of the native population. The statistics are not sufficient for a just comparison between the wage workers of the two countries, but, in so far as they go, they imply very distinctly that people here are very much better fed than there.

During the last dozen years the author has conversed with many observers, including a considerable number of statisticians of the best repute in the United States and in Europe, and has found among them a practical unanimity of opinion to the effect that the workingman in this country is much the more efficient. The statistics regarding this subject are very meager. Accurate details are much to be desired. An investigation which should bring them is certainly called for. Meanwhile it would seem reasonably safe to assume that the consensus of observers is right as to the general principle that, on the whole, people in the United States do more work than do people in Europe.

Regarding wages on the two sides of the Atlantic, the statistics are very extensive, and the advantage in favor of the American workingman is a familiar fact.

Discussions of this sort are entirely outside of the province of the chemist, but to a layman in political economy the parallelism between food, work, and wages in the United States and in Europe is very striking.

THE NUTRITION OF THE WORKINGMAN AND HIS ELEVATION.

Among the standard illustrations of the relation between the food consumed and the work done is that of the experience with English and French workingmen in the building of a railroad many years ago in the north of France. The contractor, the well-known Englishman, Mr. Brassey, found that the English navvies were much more efficient than

the French laborers with the pick and shovel. But, on looking into the matter, it appeared that the Englishmen were much the better fed, and when more food was given to the Frenchmen there was a corresponding increase in the work which they performed.

Among the persons engaged in the railroad enterprise thus referred to was a young Englishman who afterwards came to this country and became very prominent as an employer of labor and manager of large manufacturing enterprises. Among his observations are some of great interest. He says that he has had occasion to observe large numbers of English laborers who have come to this country and entered his employ, and that the change which comes over many of them is very noticeable. Under the stimulus of the larger experience, the more favorable surroundings, and better opportunities, their ambition is excited, they try to see what they can make of themselves, and the result is a noteworthy development in their personal character as well as in their working capacity.

This last observation is very suggestive. The merely physical factors—food, clothing, and shelter—are not enough to elevate a man. There must be the conditions about him and the spirit within him to enable him to utilize them. The material conditions, environment, and spirit must all be present if he is to rise to the level where a man ought to live.

The facts and observations above cited have a profound significance. The dietary statistics, taken with the collateral facts, lead to the inference that ordinary people have with us what only the exceptionally well fed have on the other side of the Atlantic—the food they need to make the most of themselves and their work. Indeed, is it not safe to say that, so far as the facts at hand go, they imply very distinctly that to the American workingman is vouchsafed the priceless gift which is denied to most people of the world, namely, the material conditions, including especially the liberal nourishment, which are essential to large production, high wages, and the highest physical existence, and that, as a corollary, he has a like peculiar opportunity for intellectual and moral development and progress? The saddest part of the picture that one sees among the industrious and worthy members of the poorly paid and poorly fed classes in Europe is not the physical want, but the spiritual poverty, the lack of buoyancy, the mute, hopeless endurance of their lives. And, by contrast, the happiest feature in the condition of wage workers with us is not simply that they have better food, better clothing, better houses, and a better material existence in general, but that they have what is more important—and these things help to bring them—the vigor, the ambition, the hope for higher things, and that their effort leads them to the realization of their hope.

The general principle here urged is that liberal food, large production, and higher wages go together. If this be true, the connection between the American's generous diet and his high wages is very clear. The question naturally follows, What is to be done for the future mainte-

nance of the position of our laboring people at home and in their competition with others in the markets of the world? Part of the answer, at any rate, must be sought in a reform in the purchase and use of food. Instead of our present wastefulness, there must be future saving. With increase of population and closer competition with the rest of the world, the abundance which tempts us to our lavishness must grow gradually less, and closer economy will be needed for living on our present plane of nutrition.

FOOD OF PEOPLE WITH SCANTY NOURISHMENT.

The statistics of the food consumption of people of the poorer classes deserve more notice than can be given to them here. Studies of families in Philadelphia and Chicago were made at the College Settlements in the former, and at the Hull House in the latter city, by Miss Amelia B. Shapleigh, as holder of the Dutton fellowship of the College Settlements Association. They represent a line of inquiry for which the College Settlements are in peculiarly favorable situation to carry out by virtue of their intimate and sympathetic relation with the people in the poorer quarters of the cities, where they are located. The variations in the quantities of nutriment, as ascertained in these investigations, are very wide. Here are the figures for pounds of protein and fuel value of the food per man per day:

	Protein.	Calories.
Twenty-five families in the poorest part of Philadelphia:	*Pound.*	
Largest dietary, German family	0.45	5,235
Smallest dietary, negro family	.15	1,630
Average of 25 dietaries	.24	3,235
Twenty-six families in the poorest part of Chicago:		
Largest dietary	.31	4,950
Smallest dietary	.21	2,195
Average of 26 dietaries	.26	3,425

The standard above proposed for a man at moderate work calls for 0.28 pound of protein and a fuel value of 3,500 calories. Voit's German standard calls for 0.26 pound of protein and 3,050 calories of energy. It would appear that these people have on the average about enough for normal nourishment. Assuming them to be engaged in moderately hard muscular labor, the figures give them more than the accepted European standards provide, and very nearly as much as is called for in the more liberal American standard. The food of the German family, with 0.45 pound of protein and 5,235 calories of fuel value, was excessive unless the members were doing very hard muscular work. But while some had so much—and here is the sad story the figures tell—others were underfed. Men with only 1,600 calories of energy in their daily food live on a very low nutritive level.

This low level of nutrition appears in the dietaries of poor people in Europe. The condition of many of these people, as depicted in the

detailed accounts of their ways of living and their nutrition, is most pathetic. These accounts describe factory girls with wages of $1.20 and less per week and 1,600 calories of energy in their daily food; families of mechanics and laborers that are no better nourished; and whole communities whose incomes, nutrition, and standards of living are on a plane far below anything of which most people in the United States have any conception.

Neither the European nor the American figures for food consumption thus cited are absolutely correct. Very few of them represent accurate measurements, weighings, and analyses of the food; the majority are more or less crude estimates. Furthermore, they represent, in most cases, the food purchased, and make no allowance for amounts wasted, which doubtless averaged much larger in the American than in the European dietaries. A considerable deduction for such waste, perhaps 5 and possibly as much as 10 per cent, would have to be made from the quantities given for the American dietaries to put them on the same basis with the European.

The American figures are nearly all from Massachusetts and Connecticut. The European come very largely from Germany, and especially from Saxony and Bavaria. It would be going too far to assume that the figures, if they were entirely accurate for the cases studied, would be exact measures of the food consumption in the localities where the studies were made. It would be still less justifiable to claim that the New England dietaries here given represent accurately the average food consumption for working people in the whole United States, or that the German dietaries cited are typical for wage workers throughout Europe. It is difficult to avoid the impression that, in so far as the figures fail to represent the average facts on the two sides of the Atlantic, the American data come fully as near, if not nearer, to the average conditions in the United States than the German ones do to the conditions in central and western Europe, for we have not in the United States the large numbers of the underfed poor who are so numerous among the working classes there. In other words, while there seems to be no reason to think that the people in New England, whose dietaries have been studied are better fed than the average people of their occupations elsewhere in the United States, there does seem to be good reason to doubt whether factory operatives, mechanics, and other wage workers in general on the continent of Europe have as abundant and nutritious food as the tabulated results of the dietary studies thus far made imply and the dietary standards of Voit and others call for.

NUTRITION AND WORKING POWER—THE BODY AS A MACHINE.

The thesis defended in this article is that, to make the most out of a man, to bring him up to the desirable level of productive capacity, to enable him to live as a man ought to live, he must be well fed. This

is only part of the story, but it is an essential part. The principle is one that reaches very deep into the philosophy of human living.

Part of the principle is found in the fact that the human body is a machine. Its efficiency for muscular work depends upon how strongly it is built, and how much fuel is used to give it power. If a machine is strong, well built, and in good order, the work it does will, within certain limits, vary with the fuel. The bodily machine, however, differs from those made of iron and steel in that its building material and fuel are from the same source, namely, the food. A well-nourished body is a machine with abundance of good material for building and repair, and well supplied with the most effective fuel.

So long as a man's labor is the labor of his hands, so long as his power to work depends upon his use of his body as a machine, so long will the amount of work he can do be more or less as he has more or less ample nourishment.

Of course, a workingman is more than a machine. His capacity for work depends upon more than brute force. There is no wish to underrate the other factors of the wage worker's efficiency—environment, intelligence, skill (especially in the management of machinery), ambition, and will power. The point is that, among the factors, food is one, and a more important one than is commonly realized.

ERRORS IN OUR FOOD ECONOMY.

Scientific research, interpreting the observations of practical life, indicates that we make a fourfold mistake in our food economy. First, we purchase needlessly expensive kinds of food. We use the costlier kinds of meat, fish, vegetables, and the like, when the less expensive ones are just as nutritious, and, when rightly cooked, are just as palatable. Many do this under the impression that there is some peculiar virtue in the dear food materials, and that economy in their diet is somehow detrimental to their dignity or their welfare. And, unfortunately, those who are most extravagant in this respect are often the ones who can least afford it. Secondly, our diet is apt to be one-sided. It often does not contain the different nutritive ingredients in the proper proportions. We consume relatively too much of the fuel ingredients of food—those which are burned in the body and yield heat and muscular power. Such are the fats of meat and butter, the starch which makes up the larger part of the nutritive material of flour, potatoes, and sugar, of which such enormous quantities are eaten in the United States. Conversely, we have relatively too little of the protein or flesh-forming substances, like the lean of meat and fish and the gluten of wheat, which make muscle and sinew, and which are the basis of blood, bone, and brain. Thirdly, we use excessive quantities of food. This is true not only of the well-to-do but of many people in moderate circumstances also. Part of the excess which is bought is thrown away in the wastes of the kitchen and the table, so that the injury to health

from overeating, great as it may be, is doubtless much less than if all of the food we buy were actually eaten. Probably the worst sufferers from this evil are the well-to-do people of sedentary occupations—brain workers as distinguished from hand workers. Not everybody eats too much; indeed, there are some who do not eat enough for healthful nourishment. But there are those, and their name is legion, with whom the eating habit is as vicious in its effect on health as the drinking habit, which is universally deplored. Fourthly and finally, we are guilty of serious errors in our cooking. We waste a great deal of fuel in the preparation of our food, and even then a great deal of the food is very badly cooked. A reform in the methods of cooking is one of the economic demands of our time.

PURCHASE OF NEEDLESSLY EXPENSIVE KINDS OF FOOD.

One of the ways in which the worst economy is practiced is in the buying of high-priced foods. For this error, prejudice, the palate, and poor cooking are mainly responsible. There is a prevalent but unfounded idea that costly foods, such as the tenderest meats, the finest fish, the highest-priced butter, the choicest flour, and the most delicate vegetables possess some peculiar virtue which is lacking in the less expensive materials. Many people who have small incomes and really wish to economize think it beneath them to use the cheaper meats and inexpensive but substantial groceries. Many, too, labor under the false impression that the costly food materials are somehow essential and economical. The maxim that "the best is the cheapest" does not apply to food. The "best" food, in the sense of that which is the finest in appearance and flavor and is sold at the highest price, is rarely the most economical for people in good health. The food that is best fitted to the real wants of the user may be of the very kind which supplies the most nutriment at the lowest cost.

Illustrations of the relative cheapness and dearness of food materials were given in the previous pages. What is here urged is that the facts are not understood, and that the ignorance results in great waste of hard-earned money. If a man has an income of $5,000 a year, he can afford tenderloin steak, oysters at 50 cents a quart, and young chicken and early strawberries at the high prices that prevail when they first come into the market. He can likewise, if he wishes, pay $100 for an overcoat, and his wife may indulge in twenty-dollar bonnets. But if his yearly income is only $1,000, these luxuries will be beyond his means, and if he has but $500 a year for the support of his family, such extravagance would be unpardonable. So far as the overcoat and bonnet are concerned, everyone would agree to this statement, but when it comes to a matter of food economy a great many people of small incomes would object to the principle most decidedly.

The larger part of the price of the costlier foods is paid for appearance, flavor, or rarity. The sirloin of beef is no more digestible or

nutritious than round or rib, although it is more tender, and to cook it so as to get the finest flavor is an easier matter. Saddle Rock oysters, fresh from the shell, at 50 cents a quart, are worth no more for nutriment than the ones that are sold in the same market at half the price, and a quart of milk contains as much nutriment and in fully as digestible form as either. Salmon has no higher food value in the first of the season at $1 than later at 25 cents a pound, and at either time it ranks as food just about on a level with mackerel, which is often sold at 10 cents per pound or less. The expensive food materials are like the expensive articles of adornment. They are very nice if one can afford them, but they are not economical. The plain, substantial, standard food materials, like the cheaper meats and fish, milk, flour, corn meal, oatmeal, beans, and potatoes, are as digestible and nutritious and as well fitted for the nourishment of people in good health as any of the costliest materials the markets afford.

In the traditional diet of the Scotchman, oatmeal and herring are very prominent. Both contain large quantities of protein and thus supplement potatoes and flour and make a well-balanced diet. These materials are of the cheapest kinds, but they are none the less nutritious on that account, and the strongest possible evidence of their fitness for nourishment is found in the physical and mental vigor of the people nourished by them.

The case is similar with the famous New England dishes of codfish and potatoes, pork and beans, and bread and milk. These are all comparatively inexpensive. Potatoes furnish a great deal of fuel material in the form of starch, but they lack protein. The nutritive material of codfish consists of protein and little else. A little fat in the form of butter added to the protein of the codfish and the starch of the potatoes makes a well-balanced, digestible, and nutritious food. Beans are likewise rich in protein, and have large quantities of carbohydrates also, but they are lacking in fat. When they are heated in water and then baked with a little fat pork, they make a dish which is chemically rational, gratifying to the palate, highly nutritious, and very inexpensive. Milk is one of the most nutritious of foods. Bread is the very "staff of life." It is not well to live on bread alone, but meat and milk go well with it, and experience anticipated chemistry by centuries in certifying to the value of such combinations. The inhabitants of the country districts of New England have not lacked in sturdiness of mind or body with such things as these for nourishment. Doubtless, one reason why this diet, at once so rational and so well chosen, came into vogue was that it was so economical. But the low cost alone could hardly explain the use of codfish and beans to furnish protein to supplement the carbohydrates of wheat flour, corn meal, and potatoes, and the fat of pork, and thus make fit nourishment for such people as the early New Englanders and their descendants have proved themselves to be. Their dietary practice is instinctive, but is it not one of those

cases where the experience of communities and generations has been, unconsciously, but none the less accurately and surely, formulated into unerring instinct? It was "plain living, with high thinking." If there had been luxury to tempt, instead of necessity to restrain, doubtless the earlier generations of people in this region might long since have acquired the evil habits of food selection which are so prevalent to-day.

The writer has spoken of the dietary usages in New England because he is personally more familiar with them and because most of the dietary studies thus far made are of people in that part of the country. All that he has observed implies that the conditions are much the same in other parts of the country. The investigations now beginning in the West and South will doubtless throw much light upon the dietary practices there.

WASTE OF FOOD.

The studies of food consumption above cited give a number of illustrations of the waste of food. Among the dietaries examined by the Massachusetts labor bureau was that of a machinist in Boston who earned $3.25 per day. The following figures show what the dietary furnished, its cost, and how it might have been altered:

	Protein.	Energy.	Cost.
	Pound.	*Calories.*	*Cents.*
In food purchased	0.40	5,640	47
If one-half the meats, fish, lard, milk, butter, cheese, eggs, sugar, and molasses had been subtracted	.12	1,650	19
There would have remained	.28	3,990	28

The standard proposed by the author for a laboring man at moderately hard work provides 0.28 gram of protein and a fuel value of 3,500 calories. This man was engaged in rather hard work and may have needed more. His family, however, consisted only of himself and wife. The calculations allowed his wife eight-tenths as much as himself. If she had the muscular work of an ordinary housekeeper, even the reduced dietary would have been excessive for her, and a share of that thus allotted to her would have been available for her husband. In other words, by the above calculation, the family might have dispensed with one-half of all their meats, fish, eggs, dairy products, and sugar, thus saving 40 per cent of the whole cost of their food, and still have had all of the protein and much more fuel value than is called for by a standard supposed to be liberal.

In this instance no attempt was made to learn how much of the food purchased was actually consumed and how much was rejected, but, for the sake of the health of this man and his wife, it is to be hoped that a large part of the food went into the garbage barrel.

In the case of a college students' boarding club, of which three successive dietaries were studied, estimates were made of the waste. In the first dietary the quantity of food purchased was so large as to supply 5,345 calories per man per day. The matron who attended to the cooking of the food and the care of the table was a very intelligent, capable woman who had been selected because of her especial fitness for the care of such an establishment. The steward, who purchased the food, had been chosen as a man of business capacity. Both thought that but little of the food was left unconsumed. "All the meat and other available food that was not actually delivered to the men at the table," said the steward, "was carefully saved and made over into croquettes. Men who work their way through college can not afford to throw away their food." But actual examination showed that about one-tenth of the food was thrown away with the table and kitchen refuse, so that the amount actually eaten was 4,825 calories. The next term the food was reduced so as to furnish 3,875 calories in that purchased; but over one-tenth was rejected, so that the amount actually eaten was 3,415 calories. In the third dietary the fuel value of the food purchased was 3,680 calories, but in this case the waste amounted to about one-seventh, so that the amount eaten was 3,110 calories. Even this was certainly a very liberal allowance physiologically, and it was entirely satisfactory to the club.

Another form of waste is that which comes with the trimming out of the bone and fat of meat at the butchers' shops. People often do not care to utilize the bone for soup, valuable as it is for the purpose; and many object to the large lumps of fat, which is entirely natural in view of the excess of fat in our ordinary diet. The butcher, in his haste, is apt to cut out more or less of the lean with the bone and fat, and his customers are generally so little inclined to economize as to make no objections.

The waste of food of which we are speaking is really worse from the pecuniary standpoint than it seems, because so much of the material rejected at the table, as well as at the butcher's, consists of meat, in which the nutritive ingredients are in their costliest forms. The protein of beef, for instance, is several times as expensive as that of flour.

Just where and among what classes of people this waste of food is worst it is not possible to say, but there is certainly a great deal more of it in the United States than in Europe. There may be more in boarding houses than in private families, and still more in hotels and restaurants. The worst sufferers from it are, doubtless, the poor, but the large body of people of moderate means, the intelligent and fairly well-to-do wage workers, are guilty of similar errors in this regard.

THE FOOD OF THE POOR.

That the rich man becomes richer by saving, and the poor man poorer by wasting his money, is one of the commonest facts of experience. The most wasteful people in their food economy are the poor. Not

only do they waste in the same ways as the well-to-do, but often, if not generally, they are less inclined to economize, and the sad side of the story is that their wastefulness deprives them of the comforts and even necessities of life which otherwise they might enjoy.

Sometimes this bad economy is due only to ignorance. The School of Sociology in Hartford, Conn., is undertaking some inquiries into the food supply in that city. The first family visited was that of an Irish coal laborer, who earns $8 a week when he has full work. The week the inquiry was begun he earned a little over $6; the week before he had only work enough to bring $2.50. The family consists of himself, wife, and five children. The day on which the inquiry began they spent 35 cents for bread. Service as a cook in a well-to-do family before she was married had shown the mother how to make good bread. She had plenty of spare time to make it at home, and 13 cents would have paid for the flour, yeast, and other materials, including the extra coal, needed to make the day's supply, which she had bought of the baker. She had not thought so far as to see that she might thus have easily saved 23 cents a day in that item alone. She was, however, wise enough not to get the highest-priced meats, and she did try in various ways to economize as best she knew how. But, nevertheless, she bought eggs at 25 cents a dozen, not realizing that they were for her a very dear food. The result of the examination of the dietary showed it to supply just about four-fifths as much nutriment as the American standard above quoted would require for people at moderate muscular work. By wiser management the family might have had the full amount at considerably less cost.

One fruitful source of this bad economy is the prejudice against the cheaper kinds of food, and the impression that the finer and costlier kinds have some special virtue. With this is a false pride which considers economy in food a thing unworthy of the buyer's dignity. A series of investigations lately begun in New York City have brought out some striking illustrations of this unfortunate fact. Among the families visited is one of seven persons, so poor that the mother has not a dress in which she is willing to be seen on the street of even the poor quarter where she lives. She therefore stays in the house day after day, giving herself up to constant drudgery. The cost of food for the family is $14 per week, or $2 per person. The markets of New York, including those of this district, afford excellent food at extremely low prices, so that the family might be well nourished at half the expense. But these people, some of whom really wish to economize, are the victims of a theory. They think they must have "the best." They buy the nicest and costliest cuts of beef, the tenderest chicken, the earliest spring vegetables, and other things in like manner, and pay high prices for them. They will doubtless continue to do so until they learn that their policy is an unwise one, and why it is unwise.

The especial attention of economists, teachers, physicians, and clergymen is invited to this subject. To the statistician, the economist, and the sociologist, it is certainly inviting. The fundamental facts that the cost of food absorbs half the wage worker's earnings, and that his capacity for work is so intimately dependent upon his diet, justify this assertion. To the investigator there is the special attraction that the subject is comparatively new and that the field of inquiry is one which is only beginning to be explored. It is due largely to the farsighted appreciation of this principle by Dr. Carroll D. Wright that a considerable share of the data cited in the previous pages have been gathered, since his cooperation as chief of the Massachusetts Bureau of Labor, and later of the United States Department of Labor, made the investigations possible.

In his last annual report the Secretary of Agriculture has called attention to the desirability of instruction regarding food economy in the common schools of the country. A communication lately received from Dr. W. T. Harris, United States Commissioner of Education, gives emphatic support to the same proposition. Conversations with a number of leading educators upon the subject have shown a surprising and gratifying unanimity of conviction in this regard. Doubtless, the reason why the subject has not been more dwelt upon in the past is that the science has been so little developed. But the research of later years has certainly brought enough material for a chapter, and a most useful one, in the schoolbooks, and there is a prospect that such a chapter will be introduced in a number of the text-books on physiology which are in use in the schools of the country.

NEED OF RESEARCH.

What is now most needed is research. Of the fundamental laws of nutrition we know as yet too little. Of the actual practice of people in their food economy our knowledge is equally deficient. It is, therefore, most fortunate that, among the forms of inquiry which are being prosecuted by the General Government in the interests of the people, the study of the food and nutrition of man has at length come to be included. At the request of the Secretary of Agriculture, an appropriation of $10,000 was made by Congress for the current fiscal year for investigations on the nutritive value of human foods, with a view to determining ways in which the dietaries of our people might be made more wholesome and economical. The supervision of this work was assigned to the Director of the Office of Experiment Stations, and the writer was appointed special agent in charge of the investigations. Studies of food supply and consumption, and of the dietaries of people of different occupations, have been begun in a number of representative localities, both North and South. In some of these inquiries the special object is to find what food materials people actually buy, how much they pay for them, what nutriment they contain, and what is the

relation between the actual nutriment and the cost; in other cases studies of actual dietaries are made with a view to learning what are the kinds and amounts of food materials actually consumed by people in different places, of different occupations, and under different conditions. In the prosecution of this work the fundamental idea will be to learn as much as practicable of the food economy of our people and the ways for its improvement. Methods of investigation and some of the more scientific problems of human nutrition are also being studied. More thorough study of the laws of nutrition of man is very much needed. On this subject there are many theories, but comparatively little exact information. The necessary researches will require much time and effort, and will be comparatively costly; but until they are made many of the conclusions regarding the nutritive value and digestibility of food will not rest upon a sure basis of ascertained facts. The results of previous investigations in this country and abroad are being compiled for the information of our people. Congress having increased the appropriation for this purpose to $15,000 for the next fiscal year, the scope of the investigations will be somewhat enlarged, and it is hoped that before long results of great value will be obtained. The practical results of investigations relating to food materials and their proper use will be explained concisely and clearly in a series of popular bulletins on food economy, the first of which, Farmers' Bulletin No. 23, Foods: Nutritive Value and Cost, has already been issued.

Until now much that has been done has been at private expense. But in this case, as in so many others, the results of individual effort have opened the way for the larger inquiry and demonstrated its usefulness, so that public funds which are to be used in investigations for the public benefit may be applied in this direction also. But much of the abstract research that is pressingly demanded requires peculiar facilities for its production, such as are found only in the laboratories and libraries of the great educational institutions, and is dependent for its best development upon the intellectual attrition and the opportunities for continuous study which such establishments alone can offer. In the European universities these facilities are provided by the Government; with us they depend upon private munificence. The endowment of such research would bring results of the highest value to the world, and to the donor the richest reward that a lover of his fellow-man can have.

PURE SEED INVESTIGATION.

By Gilbert H. Hicks,

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Under present conditions, success in agriculture and horticulture requires greater effort than ever before. Owing to the development of railways and other means of rapid transportation, farm and garden products from nearly all parts of the globe can be laid down in our markets in a very short time. Besides this, modern machinery, together with the use of improved methods in preparing and harvesting crops, and the competition of cheap foreign labor, make it an absolute necessity for the American husbandman to exert all his skill if he expects to secure profitable returns for his efforts. While American agriculture has made great progress in nearly all directions, one of the essential requisites to success has been largely overlooked or underestimated. We refer to the matter of planting pure seed of the best germinating qualities.

NECESSITY OF SEED INVESTIGATION AND CONTROL.

An examination of many of the seeds of common vegetables and forage plants reveals the fact that an immense amount of poor seed is sold to American farmers and gardeners. While other countries for many years have been investigating this subject, with a view to protecting their agriculturists from abuses in the seed trade, no particular notice has been directed to the matter in the United States, except at a few of our experiment stations. At the same time, great apathy prevails among those who purchase seed. Seed for corn, wheat, and other grain crops, indeed, is usually selected, with more or less care, from crops harvested on one's own farm or in the neighborhood, where there is adequate means of knowing its real value, and yet it must be admitted that, under the circumstances, more frequently than not, the selection does not receive the thought and care which the importance of the results involved demands. On the other hand, in the case of clovers, grasses, and various forage and garden plants, most of the seed is purchased in the general market and the buyer has little or no knowledge of its history and excellence. It may almost be said that the average farmer buys the cheapest seed in the market and trusts entirely to luck for it to produce the desired crop. Such seed is dear

at any price, and is the principal source of the hosts of bad weeds which are to be seen upon many farms—weeds whose eradication costs vastly more than the few cents per pound extra for which good seed might have been obtained. However, in many cases, even the highest-priced seed, purchased from reputable dealers, falls far below the standards which should prevail.

While competition might be expected to regulate this evil to a large extent, as a matter of fact there is so little accurate knowledge upon the subject of seeds among our people at large, and such a lack of public sentiment and of laws requiring dealers to furnish seed of requisite purity and germinating quality, that the buyer is placed largely at the mercy of the dealer. While seedsmen, in the main, may have perfectly honorable intentions with respect to the wares they sell, it is still the fact that they are in the business for profit, and naturally look out for their own interests. It is also equally true that some of them indulge in the most fraudulent practices, and that, both through carelessness and design, a great deal of poor seed is sold in the market in this country every year.

Another evil, resulting from the lack of information upon this subject and of seed-control methods, is found in the poor reputation which American seed has acquired in some foreign countries. It is desirable that the foreign trade in American-grown seed shall be encouraged so far as possible; but in some countries such a prejudice exists against our seed that it is very difficult for it to gain a foothold. In many cases this prejudice is entirely unfounded; but it is believed that a decided improvement may be made in the quality of American seed by calling proper attention to the subject and by the inauguration of seed-control work in this country. Such investigation will serve the best interests of honorable and careful seedsmen as well as of those who purchase seeds.

ABUSES IN THE SEED TRADE.

The need of a seed investigation, and of some sort of seed control, will be more evident if we note in some detail the evils resulting from fraud or carelessness which now abound in the seed trade. One of the primary requisites to good seed is purity, and the use of adulterations forms one large class of abuses. Herein are included the admixture both of ingredients positively deleterious and of such as are merely worthless. The deleterious ingredients consist of the seeds of noxious plants or weeds. The danger from this source is largely due to the use of foreign seed.

While seed-control agitation in Europe has resulted in a marked improvement of home stocks, it does not prevent the shipment of poorly cleaned seed to other countries, and as a result a large proportion of our inferior seed comes from abroad. Nearly all of our worst weeds are of European origin, and by far the greater part of them have been

introduced into American soil through impure seed. In the case of the Russian thistle, we have a foul weed which now covers over 35,000 square miles of territory, and seriously interferes with agriculture in six or seven States. The seeds of this plant were brought to America a little more than twenty years ago in Russian flaxseed.

As illustrating the possibility of the introduction of foreign weeds through seed, it might be stated that of the common garden and forage plants, such as alfalfa, beet, borage, broccoli, Brussels sprouts, cauliflower, chicory, cress, endive, kohl-rabi, radish, salsify, spinach, and turnip, the seeds are grown abroad, as are also the seeds of many of our grasses, such as crested dog's tail, sheep's fescue, meadow foxtail, perennial rye grass, and sweet vernal grass. Of the following vegetables about one-half of the seeds are imported: Carrot, eggplant, leek, onion, parsley, parsnip, and pepper. In the following cases a large portion, though perhaps not one-half, of the seeds are foreign grown: Cabbage, celery, chervil, kale, and lettuce.

Of course, the same cause operates within the limits of this country, foreign plants, when once introduced, being disseminated in impure seed. Thus the prickly lettuce is spread in clover seed, and the Russian thistle to some extent in oats, flax, and alfalfa. Our native weeds are distributed to a greater or less extent in the same manner.

It has been said upon good authority that scarcely a commercial seed is entirely free from foreign admixture, owing either to accident or design. The practice of adulterating clover seed with fine stones and sand is common in France at the present time. In one sample from that country examined last year was found 9.69 per cent of artificially colored yellow quartz stones, and 13.26 per cent of uncolored brownish sand. Similar instances have been reported recently from two of our American experiment stations. Some years ago a firm was discovered in Bohemia which was engaged in supplying seed dealers with both colored and uncolored quartz sand for purposes of adulteration, at prices ranging from $1 to $2 per hundredweight.

Another common method of fraud consists in mixing old or "dead" seeds with fresh material. In some cases seeds of an entirely different variety or species are thus mixed with good seed. Care is generally taken, of course, to employ seeds that are so similar in shape and appearance as to make detection difficult to the ordinary observer. To prevent the fraudulent seed from growing, and thus disclosing the fraud, it is first killed by heating or chemicals. In this way the seeds of black medic are mixed with those of red clover. "Killed" seeds of charlock are frequently mixed with those of rutabaga and turnip, which it resembles very closely. A certain family in London made a business of supplying seedsmen with "killed" seeds of charlock for twenty years. Similar practices are known to exist in America at the present time.

Another essential of good seed is vitality, or high germinating quality, and agriculture suffers greatly from failure at this point also. It is

well known that most seeds lose their vitality after a few years, and in nearly all species of plants the percentage of germinable seed decreases rapidly after one year. It is a well known fact that many seedsmen mix old stock with new in order to get rid of it, and frequently seed which looks plump and fresh is too old to germinate well. Old seed is often polished and oiled to give it a fresh, shining appearance. Thus it frequently results that the farmer is bitterly disappointed in his crop, although he has taken the utmost pains in preparing the soil and planting his seed.

Many persons test the germinating quality of seeds by observing whether they are smooth, plump, glossy, and of good weight. Seeds which sink readily in water, and pop when placed upon a hot stove, are usually considered good by farmers and seedsmen. None of these tests, however, are sufficient, and in some cases they are of no use whatever. Germination experiments, weighing, and microscopic examination are necessary to furnish a proper knowledge of the condition of seeds.

A third necessary quality of good seed is genuineness; that is, it must be what it pretends to be. Serious disappointment often comes from planting seed which turns out to be of a different variety from that which was ordered. One of the most common practices of a certain class of seedsmen is to give seed a high-sounding name, as, "Mammoth," "Extra Early," "Golden Wonder," etc., and by lavish descriptions and highly colored plates the impression is conveyed that a very superior variety is being offered for sale. In most cases such plants prove to be some well-known variety whose seed could have been purchased for a mere fraction of the amount charged by the advertiser.

Many of our grass seeds, as found in the market, are not entirely true to name. A common method of adulteration in this case consists of mixing seed of wild or otherwise inferior grasses with that which sells for a high price. Thus tall fescue seed, which is sold for 20 cents a pound, is mixed with English rye grass, which sells for 12 cents. The two kinds of seed are so near alike that a professional seedsman can scarcely tell them apart. The seed of English rye grass, being cheap, is also used to adulterate that of Italian rye grass.

More than one of these defects are liable to occur in the same package of seed. This comes about naturally when, as is the case with large amounts of commercial seed, the impurity or low vitality is due to careless methods of growing and cleaning. Such seed contains a large amount of straw, dirt, chaff, and other foreign substances, as well as a great number of weed seeds. This is especially true of the seeds of imported grasses and other forage plants; also, to a considerable extent, of imported garden seeds. Many American seedsmen "rogue" their fields carefully before harvesting the seed. In this case, care is taken to eradicate, so far as possible, all of the bad weeds. This is the only certain method of securing pure seed, for the best cleaning machines

can not take out all weed seeds. However, in many instances, seedsmen "farm out" different seed crops, to be raised in a smaller way by farmers and others. In such cases, less care is usually taken to secure good seed than when the crop is raised by the seedsmen themselves upon a large scale. Very few kinds of grass are raised for seed purposes alone; hence most grass seed is obtained from meadows or places where different species are found growing together. Again, most grasses mature their seeds very unevenly, and too little care is taken that all of the seed shall be ripe. This accounts, to a large extent, for the low vitality of so much of our grass seed. Weeds are also frequently allowed to grow in meadows from which grass seed is taken.

Examples might be multiplied indefinitely of cases in which impure seed has been sold either through gross carelessness or with fraudulent intent. Samples of the seed of Kentucky blue grass examined at the North Carolina Experiment Station contained 35 per cent of weed seeds, dirt, and chaff. In a test at the Connecticut State Experiment Station, a few years ago, 17 samples of orchard-grass seed, obtained from regular dealers, were examined. One of them contained no orchard grass whatever, but consisted principally of perennial rye grass, a very inferior species. Five other samples contained, on an average, 25 per cent of this grass seed, while of the entire lot only 40 per cent germinated, the amount germinating in one case being only 4½ per cent. At the Iowa Experiment Station, a sample of fiorin-grass seed, purchased from one of the most reliable seedsmen, and costing 42 cents a pound, was found to contain more than one-third of its weight of sand and chaff. A package marked "Burnet," costing 16 cents a pound, contained 47 per cent of sainfoin, which costs 6 cents a pound. A pound of orchard-grass seed in a sample examined contained over 1,400 seeds of sheep sorrel, a worthless weed, as every farmer knows.

The seed of clover is usually much more impure than that of any other crop. Sixty-three samples, from different parts of the United States, were tested at the Iowa Experiment Station in 1893. They showed impurities ranging from three-tenths of 1 to 67 per cent—that is, from 3 ounces to 40 pounds per bushel, and averaged nearly 3½ pounds of impurities to the bushel. A test is reported from Michigan of a sample of clover seed imported from Canada, by a firm of seed dealers in this country, which contained but 10 per cent of pure clover seed, the balance being screenings, consisting mainly of weed seeds of the worst kind. These screenings were undoubtedly ordered for the purpose of adulterating pure clover seed before placing it upon the market, as this is a frequent practice of some dealers. In the sample above mentioned it was estimated that there were over 60,000 weed seeds to the pound.

The seeds of foreign leguminous forage plants are apt to be badly adulterated and of low germinating power. Some seed of South American serradella tested last year at the seed-control station in Hamburg,

Germany, showed the low vitality of only 7 per cent. One sample labeled "red clover" contained only 1 per cent of clover seed, the balance being—alfalfa, 18 per cent; rye grass, 4; rape seed, 14; melilotus, 18, and weed seeds, 45, among the latter being 23,600 seeds of dodder. A sample sold as esparsette contained—of *Bromus mollis* (a species of grass worthless for forage), 84 per cent; weed seeds, 8; chaff, 8; and no esparsette at all! When one considers that a very large proportion of the seeds of forage plants, with the exception of clover, is imported, it is very easy to see the great need of seed investigation in this country.

SEED CONTROL IN EUROPE.

European seed control may be said to have originated in 1869, when Dr. Nobbe, director of the experiment station at Tharand, Saxony, began to devote his attention to the impurities and low germinating power of many commercial seeds for which the German farmer was paying fancy prices. The publication of the results obtained by him excited much comment and laid the foundation for the present extensive system of European seed control. At the present time there are seed-control stations in all of the principal countries of Europe, more than forty existing in Germany alone. In some cases these are distinct institutions, but frequently this work is done in connection with agricultural experiment stations, the majority of which devote more or less attention to the subject. Some countries and states have general laws concerning fraud which may be used to cover seed adulteration; but, so far as we have been able to learn, there are no laws requiring English or Continental seedsmen to guarantee their wares. The work of the seed-control stations, however, has created such a public sentiment in favor of pure seed that the best class of dealers submit samples of their seeds, to be tested by the stations, which furnish, for a stipulated price, a guaranty of the vitality and purity of the seed from which the samples were taken.

The station at Zurich, Switzerland, has contracts with more than seventy Swiss seedsmen, to whom are given certificates of guaranty for all their seeds. In 1892–93, according to the last report, this one station examined 5,958 samples of seed, requiring 16,427 separate tests. Of the analyses, 225 were made for private individuals and 109 were for seed dealers of Switzerland, while 3,244 samples were received from other countries. Over 80 per cent of the specimens examined were grass and clover seeds. This station has four experimental fields where open-air tests are conducted. It also has a garden and greenhouse, the latter being used mostly in the winter. Several germinating chambers are employed in the laboratory, part of them being kept at a temperature of 20° C. (68° F.) and the remainder at 28° C. (82° F.). The machines used at this station for sifting seeds are run with water motors. The results of the seed tests are written upon cards, upon the backs of which are printed tables giving the standards of germination and the purity

of the principal seeds of agriculture. Formulas of recommended grass-seed mixtures are also given. In the cellar of the laboratory is a machine for scratching the coats of hard seeds, like *Lathyrus silvestris*, etc., to facilitate germination; also various kinds of sterilizing and sorting apparatus. Experiments with weed seeds are also conducted at this station. Besides the director, Dr. Stebler, the working force consists of 3 assistants, 2 gardeners, and 6 women. Three of the latter attend to the germination experiments.

A large amount of seed-control work is also carried on at Vienna, Austria, under the direction of Dr. Theodor Ritter v. Weinzierl. Two thousand nine hundred and eighty samples of seeds were tested here in the year ending July 31, 1892, an increase of 450 over the previous year. At Hamburg and some other European control stations, flour, feed, and linseed meal are examined for adulterations, in addition to the regular work. At Tharandt, Saxony, the work of counting and sprouting seeds is performed to a large extent by young girls. At all of these stations fees are charged for making the examinations, although these do not, as a general thing, cover the actual expenses, which are defrayed to a large extent by Government appropriations. The leading European seed-control stations publish annual reports giving the results of their work, which are distributed to their customers and others. In order to secure unanimity in their methods of seed control, the Association of Agricultural Experiment Stations of Germany, in their meeting at Halle in 1891, agreed upon a set of laws to govern them in common in this work. As experience demands, these laws are amended and new ones adopted. Their principal features are here given, as they may serve for a basis of seed control in this country, subject to modifications demanded by American conditions.

METHODS OF SEED CONTROL.

The points to be determined in seed tests are genuineness, purity, germinating power, and actual value, all of which should be stated in the report at the close of the investigation.

AMOUNT OF SEED TO BE USED IN A TEST.

The required minimum amount of seed for a complete examination has been fixed in Europe as follows:

50 grams of grass seeds of all kinds, white and alsike clovers, spurry, cress, tobacco, poppy, anise, dill, fennel, caraway, carrot, parsley, celery, birch, etc.

100 grams of buckwheat, millet, red clover, alfalfa, serradella, esparsette, vetch, lentils, rape, cabbage, dodder, mustard, lettuce, onion, chicory, flax, hemp, teasel, woad, elder, hornbeam, conifers.

250 grams of rye, wheat, barley, oats, corn, beans, pease, lupine, soja bean, sunflower, red and sugar beet, oak, beech, "pits" of drupaceous fruits.

For ascertaining the specific weights of cereals, etc., $1\frac{1}{2}$ liters is required, since at least 1 liter of clean seed is necessary. In case dupli-

cate tests are to be made, for arbitration or other purposes, twice the above amounts must be sent in. The portion of the duplicate test which is unused in the official examination is sealed in the presence of witnesses, labeled with all the original data, and preserved for future reference.

DRAWING THE SAMPLE.

The manner of taking the sample is of great importance, as it is absolutely necessary that those who make the test should have a perfectly fair sample, and not, as is usually the case when a seedsman sends out specimens of stock, the very best samples which can be procured of seeds selected for this purpose. On the other hand, the buyer might send in for test a specimen of the worst seed he had received. The sender of seeds, whether he be a dealer or buyer, is recommended to use a clover-seed sampler for clover and other small seeds, and a grain sampler for grains, flaxseed, umbelliferous and other comparatively large seeds. For beet seed, grass seed in the chaff, etc., the entire amount from which the selection is made should be spread out on a clean surface and thoroughly mixed, and numerous small samples should be selected from various portions of this mass. The sample must be taken out, according to the directions given by the station, before witnesses, in whose presence it is placed, in a dry and firm receptacle, sealed, and sent forward. It is very essential that the packet in which seed is sent should be well fastened and thoroughly protected from dampness or other injury in transmittal.

SMALLER AVERAGE SAMPLE.

Upon being received in the laboratory, the first step is to procure a certain amount, called the "smaller average sample." This is generally done by slowly pouring out the seed from a wide-mouthed flask into a dish and taking small amounts out of this stream at regular intervals by means of a horn spoon. Or it may be poured out into a flat-bottomed dish, thoroughly mixed, and small portions taken from different parts of the dish until the desired amount is secured.

In making the test for purity it is recommended that the following quantities shall be taken at the least:

2 grams of redtop.
5 grams of white clover, alsike, velvet grass, yellow oat grass, hair grass, sweet vernal, June grass, foxtail grass, spurry, dill, caraway, fennel.
10 grams of red and scarlet clovers, alfalfa, kidney vetch, timothy, rye grasses, meadow foxtail, orchard grass, crested dog's tail, carrot, valerianella.
20 grams of serradella, maple, ash, elm.
25 grams of esparsette, millet, rape, turnip.
30 grams of cereals, lentils, buckwheat, vetch, flax, pine, fir, larch, hornbeam.
50 grams of red and sugar beet "balls," peas, beans, corn, lupine, acorns, beechnuts.

In case dodder is found in any sample, the entire amount sent in is to be used in the test.

GENUINENESS.

The fact that a certain sample is true to name is usually ascertained without difficulty from the external appearance of the seed. In doubtful cases it must be compared with a standard seed collection. However, the genuineness of varieties, and in some cases even that of species, can only be settled by a test in the field or greenhouse, for which an extra amount is charged. In many instances a microscopic study of the structure of the seed coat is very helpful.

ORIGIN OF THE SEED.

In some European control stations, particularly the one at Hamburg, great stress is laid upon the presence of weed seeds, as enabling the investigator to determine the origin of a given kind of seed under inspection. Owing to great variations in plants, due to differences of soil and climate, it would be a desirable thing for the buyer to know where his seed originated. This knowledge is very difficult to obtain, even from the best dealers, since, as in the case of clover, for example, the seed is bought up in small lots from local dealers from all parts of the country, dumped into a common elevator, cleaned, and then sold, either at home or abroad. While in a few instances the presence of the seeds of certain weeds will indicate that the seed under examination came from Europe, South America, Canada, or the United States, the ubiquitous nature of most weeds precludes any reliable data as to the origin of the seed. Especially is this true when one seeks to ascertain in what portion of the United States a given commercial seed originated. Hence many of the conclusions of certain foreign control stations with reference to the origin of American seeds, based upon the weed seeds present in samples, are unreliable. Nevertheless, this test is useful to some extent.

TEST FOR IMPURITIES.

All chaff, sand, and foreign admixtures of any nature, even if good seeds of a valuable plant, are to be considered as impurities; also seeds of the genuine species which are broken or have been so injured in thrashing or cleaning that they will not sprout.

After the smaller average sample has been weighed out, the seed is spread out carefully upon a smooth, glazed, black or white surface, and by means of a horn spatula the impurities are carefully separated out, weighed, and their percentage ascertained. This is recorded on blanks prepared for the purpose, and, so far as possible, the weed seeds are identified and noted. The latter point is important, since there is a great difference in the noxious character of different weeds, and in some instances a few weed seeds of one kind would outweigh, in their capacity for harm, many of another species. The impurities separated should be carefully sealed and preserved for reference for a year or more.

GERMINATING TEST.

The next step is to conduct the germinating test. There are so many influences which affect germination that this test requires even greater care than that for impurities.

NUMBER OF SEEDS TO BE GERMINATED.

The selection of seeds for germinating tests demands painstaking effort and good judgment in order that the seeds used may fairly represent the sample. Large, medium-sized, and small seeds, both dark and light colored, as well as those which represent different stages of maturity, are selected. In all cases duplicate tests are made, and these are repeated if a variation of more than 10 per cent takes place.

The following numbers of seeds are to be used in germination tests:

2 lots of 200 seeds each for clover and all seeds germinating easily (in about ten days).
3 lots of 200 seeds each for conifers, grasses, etc.
3 lots of 100 seeds each for beet.
2 lots of 100 seeds each for beech, oak, etc.

PREVIOUS TREATMENT OF SEEDS.

Various kinds of apparatus and various chemical solutions have been used in germination tests by means of which it was thought that the process of germination is hastened. All such artificial aids are to be rejected in seed-control work. However, it is recommended that seeds be soaked in distilled water or rain water for six to fifteen hours before being placed in the germinating chamber. Since the absorption of moisture is a natural process in germination, this soaking of seeds may be profitably employed, as the work is thereby hastened. One of the main difficulties to contend with in making germination tests is the fact that seeds become moldy after being confined in a moist, warm, and close chamber for any length of time; hence the desirability of hastening the process by all natural means.

PLACE OF GERMINATION.

The nature of the "sprouting bed" is of little importance compared with a complete control of heat, moisture, and access of air, and a certainty that the seeds used represent an average sample. Porous dishes, stout blotting paper, flannel or other thick cloth, and earth are used. In addition to the test in the laboratory, a duplicate one should be conducted in soil in a greenhouse, if in winter, and out of doors, if the season will permit. In the case of duplicate tests the average of the results obtained should be used.

TEMPERATURE.

At most of the foreign stations a constant temperature of 20° C. (68° F.) is used, except in the case of the following grasses: Poa, Aira, Glyceria, Phalaris, Agrostis, Alopecurus; and in the case of carrot, alder, birch, mulberry, tobacco, beet, and maize. In the instances excepted it has been found that a daily increase of temperature to

30° C. (86° F.) for six hours is advantageous, and that a much greater per cent of these species will germinate with this daily increase than with a constant temperature of 20° C. Moreover, this variation, to some extent, represents the natural difference between the temperature of day and night.

A constant temperature is secured by placing the seeds in a germinating chamber heated by gas and controlled by a thermostat, Reichert's being preferred. In ordinary tests not intended to be of a scientific nature the temperature of a living room is quite satisfactory.

DURATION OF THE GERMINATING EXPERIMENT.

After much trial it has been agreed by the German association to recommend the following periods, at the close of which the experiments shall cease:

10 full days for cereals, clovers, spurry, peas, beans, vetches, lentils, lupines, soja beans, sunflowers, rape, cabbage, mustard, dodder, flax, chicory, hemp, poppy, tobacco.
14 full days for serradella, esparsette, beet-seed balls, rye grasses, timothy, carrots.
21 full days for grasses (except meadow and rye grasses and timothy).
28 full days for meadow grasses (Poa), conifers (except white pine), birches, alders, acorns, beeches, and hornbeams.
42 full days for white pine and stone fruits.

Each day the sprouted seeds are to be counted and removed, and a careful record kept of the same. At the close of the experiment all of the moldy or "dead" seeds are counted, as well as those which remain firm and hard. Only those which sprouted are to be reckoned in the "actual" or "intrinsic" value of the test, which is obtained by multiplying the per cent of purity by the per cent germinating, and dividing by 100. Thus, if P equals the per cent of purity, G the per cent germinating, and A the actual value of the seeds tested, $\frac{P \times G}{100} = A$.

However, the seeds which are found to be "hard shelled" (those which remain apparently fresh or unswollen at the close of the test) are to be mentioned in the report, since, as may be easily seen, in certain cases an indeterminable portion of them would be likely to germinate if given sufficient time. Such hard-shelled seeds will be most likely to occur in the *Leguminosæ*, white pine, etc. However, since different samples of the same species vary exceedingly in the proportion of hard-shelled seeds remaining, it is impossible to assign such seeds any definite value in the total per cent germinating. Since more seeds will germinate under favorable artificial conditions than in the open field, a deduction of about 8 per cent is made on this account.

GERMINATIVE ENERGY.

While, as above stated, certain periods are established in the course of which different seeds are expected to germinate, it is also recognized as a fact that if the seed is fresh and otherwise good the greater part

of it should sprout in a much quicker time. This is called the period of germinative energy, and is fixed as follows:

3 days for cereals, clovers, peas, vetches, flat peas, flax, dodder, poppy, Brassica, Lepidium, radish, spurry, chicory.
4 days for cucurbits, cucumbers, beans, Poterium, spinach, lupine, buckwheat.
5 days for beet, timothy, serradella, Lotus, rye grasses, meadow foxtail, reed grass.
6 days for redtop, hair grass, Anthriscus, carrots, fennel, esparsette, sorghum.
7 days for spruce, foxtail grass, sweet vernal grass, canary grass, Deschampsia, Trisetum, Poa, crested dog's tail, velvet grass, red and sheep's fescue, Pimpinella.
10 days for fir, pines (except white pine), maple.
14 days for white pine.

TEST OF BEET SEED.

Special methods are required for testing red and sugar beet "balls," each of which contains from 3 to 7 seeds. Three separate lots of 100 balls each are selected with great care, so as to present average samples. These are rubbed slightly between the hands, soaked six to fifteen hours, then placed on blotting paper or sand at a constant temperature of 20° C. for eighteen hours out of twenty-four, the rest of the time at 30° C. In three, five, eight, and eleven days the balls are examined. Whenever 1, 2, or 3 seeds have sprouted in a single ball, they are carefully cut out with a knife, and the balance of the ball is removed to a second seed bed, which is numbered to correspond with the number of the seeds which have germinated in the balls placed therein. At the next examination the sprouted seeds are again cut out and the clusters removed to another bed, numbered to agree with the total number of seeds per ball which have sprouted. The test is closed on the fourteenth day, when the sum of all the germinating seed of each lot of 100 clusters, together with the number of unsprouted seeds, is ascertained. The average of all the clusters is taken into account, especial care being exercised not to count as seeds any cavities which were empty at the beginning of the test.

TEST OF GRASS SEEDS.

Specific methods are also required to determine the germinating per cent of all grass seeds (properly speaking, fruits) which are likely to remain inclosed in the chaff. The chaffy fruits of tall oat grass and meadow foxtail are carefully handled with a suitable instrument, such as a small spatula or forceps, to ascertain whether a grain is inclosed. Or, in the case of meadow foxtail and the smaller and more tender species, the fruit is placed upon the stage of a dissecting microscope or upon a glass plate, and the light is caused to pass through it by means of a mirror. In this way imperfect grains are easily detected and rejected from the germinating test. In velvet grass and sweet vernal the outer glumes, and in Poa the glume hairs, are removed by rubbing, so that none but sound material is used.

WEIGHING THE SEED.

The seeds used for each germinating test should be carefully weighed. Many experiments have shown that there is generally a definite relation between weight and germination of seed, heavier seeds usually germinating more promptly and giving a larger and more uniform yield than lighter ones. On this account it is desirable to note the absolute weight of a specified number of seeds from each sample tested. If preferred, several average samples of 1,000 seeds each may be weighed, instead of those used in the germinating test. The specific weight is also necessary in scientific experiments, although this is often omitted in ordinary practice.

HORNY AND STARCHY SEEDS.

In the case of cereals, account is often taken of the relative amounts of "horny" (glassy) and "mealy" (starchy) grains, since it is currently supposed that the value of cereals depends, to a large extent, upon this proportion. Whether a seed is horny or mealy is determined by cutting it open. To facilitate this process, an apparatus called a "farinatom" is used to hold a large number of seeds, say 100, in an upright position, so that all may be cut in two at once.

GENERAL NOTES.

All dishes used for germination experiments should be sterilized with boiling water or chemicals before a new test is undertaken. Too much moisture must be avoided in all cases. The laboratory for germination tests should be in a cellar or basement, since this will better permit the desired control of temperature. If possible, germination experiments should be conducted by assistants who give it their undivided attention, while the identification of seeds and the care of the seed collection should be allotted to another specialist.

EQUIPMENT FOR SEED INVESTIGATION.

MICROSCOPICAL APPARATUS.

A hand lens is necessary in the study of seeds. One with a large field, good focal distance, and magnifying power of ten to fifteen diameters is desirable. Farmers and those testing their own seeds can purchase a satisfactory glass of this kind of any dealer in optical goods for about 75 cents. For laboratory use a dissecting microscope is requisite. We know of none better than those made by Leitz, having three lenses and a camera lucida attachment.

A thick glass slide, ruled in millimeter squares, with every fifth line heavier than the rest, greatly facilitates the measurement of seeds and small fruits. Such a slide may be obtained for about $2.50.

For minute study, a good compound microscope, with the usual appliances and reagents, is essential. American instruments of a Continental pattern are to be recommended.

For studying the structure of seeds cross sections are needed, requiring the use of a microtome, together with a paraffin bath and embedding material. A drying oven for sterilizing sand, etc., is necessary.

GERMINATING APPARATUS.

For sprouting seeds some kind of equipment is needed in which the different factors governing germination, such as light, temperature, and moisture, can be controlled. Such an apparatus, devised by the author, is shown in figure 83. It consists of a square chamber, strongly

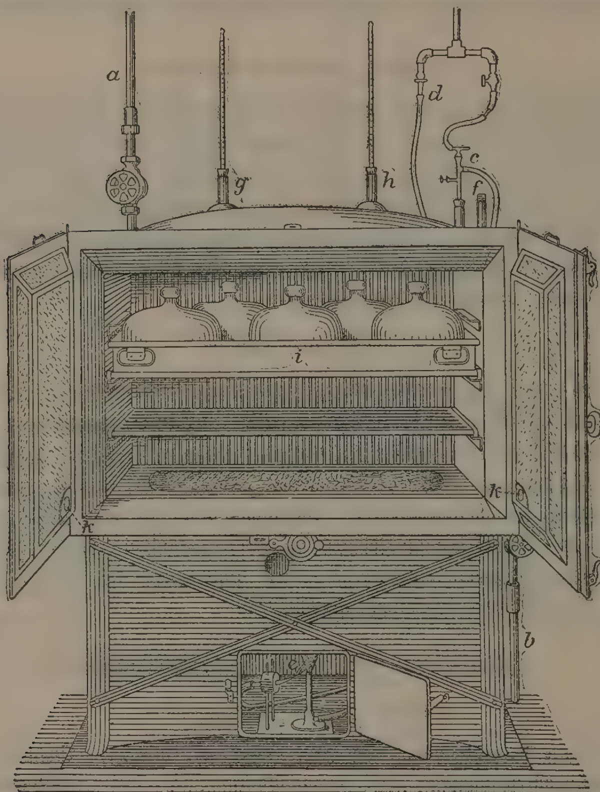

FIG. 83.—Seed-germinating apparatus used by the United States Department of Agriculture. *a*, inlet pipe; *b*, outlet pipe; *c*, thermo-regulator; *d*, "guide light" gas delivery tube; *e*, "guide light;" *f*, opening into water cavity; *g*, maximum and minimum thermometer; *h*, thermometer; *i*, germinating pan containing pots of soil covered by bell jars; *k k*, outlets for carbon dioxide.

made of heavy copper, with double walls, which are filled with water by means of a pipe, *a*, there being an outlet at *b*. In case the apparatus can not be placed in a cellar, a sufficiently low temperature may be secured by causing a continual stream of water to flow through the inlet pipe, which is inclosed in a wooden jacket kept constantly filled with ice. The lower portion of the chamber is made of sheet iron, and contains a Bunsen burner, connected with the thermo-regulator *c*, which

is used to control the temperature. A second gas-delivery tube is attached at *d*. This connects with a "guide light" at *e* to prevent the larger flame becoming permanently extinguished when the gas in the thermo-regulator is cut off by a rise in temperature. At *f* there is a second opening into the water cavity, which may be used for a U-tube, containing mercury, to serve as a safeguard against violent pressure when a continuous stream of water is used. Two holes, *g*, *h*, lead into the chamber, for the insertion of a combined maximum and minimum thermometer and for a standard centigrade thermometer. If desired, the former aperture may be used for the admission of oxygen.

Within the chamber are three movable shelves, made of galvanized iron. Upon one or more of them copper pans are placed. In these the seeds may be germinated in several ways, as shown in figures 83 and 84. If it is desired to make a great number of tests at one time, the folds of asbestus cloth, shown at *a*, figure 84, are used. These are made similar to the ones used in the ordinary Geneva tester, and consist of a double strip of cloth, as long as the pan is wide, and attached to brass

FIG. 84.—Germinating pan; *a*, "Geneva tester" seed bed; *b*, porous clay saucers, used as seed beds in different ways.

rods, which lie upon ledges projecting from the sides of the pan, an inch or so below the top. From the bottom of the pocket formed by the folds of asbestus a narrow strip of the same material projects into the water which covers the bottom of the pan. The seeds are kept moist by means of the water which is drawn up by capillary attraction. Each pocket may be taken out of the pan separately, in order to examine the seeds.

In addition to this method of germination, the seeds may be sown between damp cloths or blotters placed in saucers made of porous clay, as shown at *b*, figure 84. The saucers may contain sand, instead of blotting paper, for the reception of the seed, which in turn may be sown in pots and placed under bell jars, as shown at *i*, figure 83.

The doors to the chamber are double, the outer being of copper and the inner of glass and lined with felt. Openings are provided at *k k* for the escape of the carbon dioxide given off in germination. The outer walls of the doors may be removed and replaced with frames containing white or colored glass, if the experimenter wishes to test the effect of light or different rays of the spectrum upon germination.

The Geneva tester, so called because first used at the agricultural experimental station, Geneva, N. Y., consists of an oblong box about 14 inches in length and 11 in width, and 3 inches deep. This is provided with a copper or glass cover, and resembles the pan shown in figure 84, except that cloth pockets alone are used to hold the seeds. As usually constructed, the cloth is all of one piece, and touches the water only at the ends, which are extended into flaps. The advantage of separate pockets, with a flap to each, is that the seeds of a single test may be removed and examined without disturbing the others. The Geneva pan or some modification of it is most generally used by American experiment stations, and costs about $3. An improved form is employed by Professor Goff, of Madison, Wis. In the apparatus designed by him, the upper margin of the pan is flattened out into a wide ledge, at whose outer margin is soldered a small metal trough, into which the rim of the copper cover fits. This trough is kept filled with water, to make the union between the cover and pan air-tight. At intervals, along the inner margin of the ledge, holes are drilled to permit the escape of carbon dioxide and the entrance of oxygen. The wires holding the strips of cloth rest upon this ledge. A leveling apparatus, similar to the one used in the chemical balance, is also attached. The advantage of the Geneva apparatus over most others is the large number of tests that may be conducted at one time. In some respects, however, other sprouting beds are superior. The Geneva pan may be placed in a warm chamber to regulate the temperature, if desired.

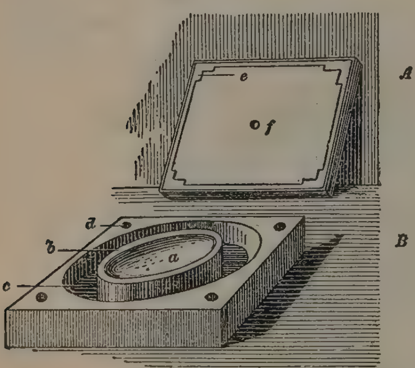

FIG. 85.—Nobbe's germinating apparatus (after Harz). *A*, cover; *B*, bottom; *a*, seed bed; *b*, wall of same; *c*, water cavity; *d*, holes where dishes containing caustic potash are placed; *e*, projections on the cover to prevent close contact with the bottom; *f*, hole for thermometer.

A simpler form of germinating apparatus, suggested by Professor Nobbe, and quite generally used in Europe, is shown in figure 85. It is made of burned, unglazed clay, 20 cm. square and 5 cm. deep. In the center is a trough, 2 cm. deep, with a diameter of 10 cm., in which the seeds are placed. Around this runs a canal, 2.5 cm. wide and 3 cm. deep, containing water. At each corner is a small cavity which may be used for the reception of a glass vessel, containing caustic potash, to absorb the carbon dioxide. The cover is also constructed of porous clay, and has a slight projection in each corner to prevent it from lying in close contact with the bottom of the apparatus. In this way free access of air is obtained. A round opening in the center admits a thermometer. Enough moisture soaks through the walls of the trough to cause the seeds to germinate. They are either dry when placed

therein, or have been previously soaked in distilled water or rain water twenty-four to thirty-six hours.

The principal advantages claimed for this apparatus, in addition to neatness, simplicity, and utility, are as follows: (1) Complete darkness is afforded. (2) All of the carbon dioxide is removed. Even without the use of potash, the currents of air carry this off to a great extent. (3) Evaporation is slow. (4) The temperature is easily ascertained, and may be regulated by the use of a thermostat.

GERMINATING APPARATUS FOR HOME SEED TESTING.

Very simple methods have been recommended for the use of farmers and others who wish to test their own seed before planting. One American experiment station recommends the use of a large pan, con-

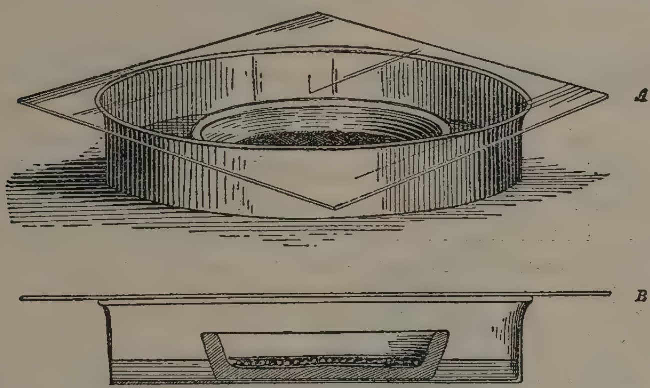

FIG. 86.—Homemade germinating apparatus. *A*, complete; *B*, section.

taining about an inch of water, inside of which a smaller and shallower flat-bottomed pan is placed, with the bottom upward. A piece of common cotton cloth is washed in boiling water, doubled, wet, and placed upon the inner pan, with its ends extending into the water. Between these folds of cloth the seeds are put.

A very simple apparatus for sprouting seeds is shown in figure 86. It consists of a shallow tin basin ("redipped" tin is best), which is given two coats of mineral paint, both inside and out, to prevent rusting. The bottom of the basin is covered with water, and a small flat-bottomed saucer of porous clay is placed inside. After having been soaked, the seeds are laid between two layers of moist blotting paper or flannel cloth. A pane of glass covers the dish, which is to be kept in a temperature of about 70° F. The atmosphere of an ordinary living room is suitable, if care is taken to set the apparatus near a stove or in some warm place at night. The basin may be left partly open from time to time, to permit exchange of air and gases. By using a good-sized dish, with small saucers, and renewing the water occasionally, several kinds of seed may be tested at once, at a trifling cost. Extremes of temperature and excessive moisture must be avoided.

SEED SAMPLERS.

Seed triers or samplers are used for obtaining fair average samples of seed. Two kinds of clover-seed samplers, used for handling all kinds of small seeds, are shown in figure 87. The upper one is 10 cm. long and 6 mm. in diameter, and, for the last 2.5 cm. of length, tapers off to a point. On one side, about 3.5 cm. above the point, there is an oval opening which extends upward for 2.5 cm. Samplers of this style cost about $1 apiece. A much better form, costing 70 cents, is shown in B. This is about the same length as A, and about one and one-half times its diameter. However, the point is sharper, the aperture twice as large, and the instrument begins to taper at once from the top. Both samplers are hollow, made of nickel, and come in cases of the same metal, so that they can be carried in the vest pocket. In obtaining samples, they are plunged into the cloth sacks which contain the seed until the oval opening is out of sight, when a small portion of seed is allowed to run out of the top of the sampler into a dish. This operation is repeated until seed has been obtained from several parts of the bag. The sample thus secured is thoroughly mixed before being tested.

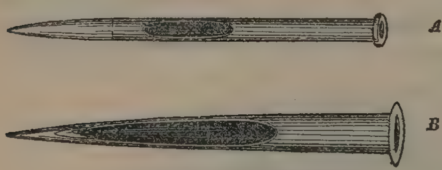

FIG. 87.—Clover-seed samplers.

GRAIN TRIERS.

Cereals and other large seeds are sampled with a grain trier. This consists of two hollow cylinders of metal, one inside of the other, about 1 meter long and 12 mm. in diameter. They are pointed at the bottom and provided with a handle at the upper end. A corresponding series of oblong openings extends at regular intervals along one side of both cylinders, which may be turned at will so as to open or close the holes. The sampler, with the holes open, is thrust into the top of a bag of grain for its entire length. When filled with seeds the inner cylinder is turned, so as to close the holes, and the sampler removed.

SIEVES.

Sieves are the most common appliance for cleaning and sorting seeds, and their method of construction is of very great importance. The frames should be made of metal, while the bottoms may consist of wire mesh or perforated plates of zinc or copper. The size, form, and position of the holes are of great significance. Figure 88 shows some of the principal forms of holes to be used. Sieves with round holes are especially suitable for fine seeds, while those with square meshes are better adapted for large, round, and coarse seeds. The sieves with oblong and triangular apertures are used for cereals, the latter especially for wheat.

Perforated metal sieves have this advantage over those made of wire: The holes are more uniform and accurate, and can be made of any size

down to one-tenth of a millimeter. On the other hand, they suffer from the obvious disadvantage that they have a less number of holes in a given space than wire sieves, thereby presenting a smaller working surface; also in the smoothness of the metal, which lessens the hopping and rolling of the seeds; hence the latter pass through less quickly than in wire sieves.

For laboratory use it is desirable to have a set of sieves of uniform size and nested as shown in figure 89, so that they may be used sepa-

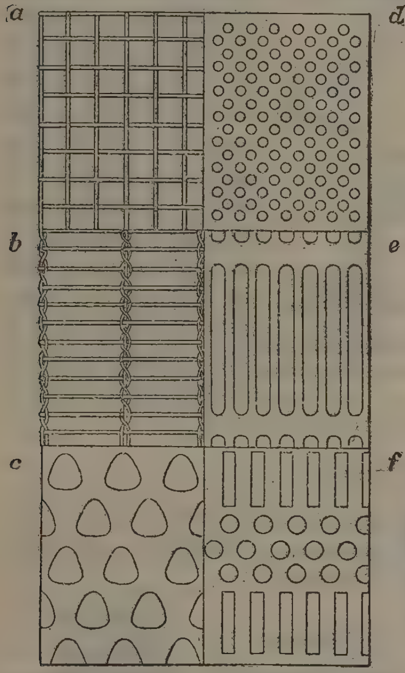

FIG. 88.—Samples of sieve meshes (*a*–*e*, after Rudolph Röber; *f*, after Settegast).

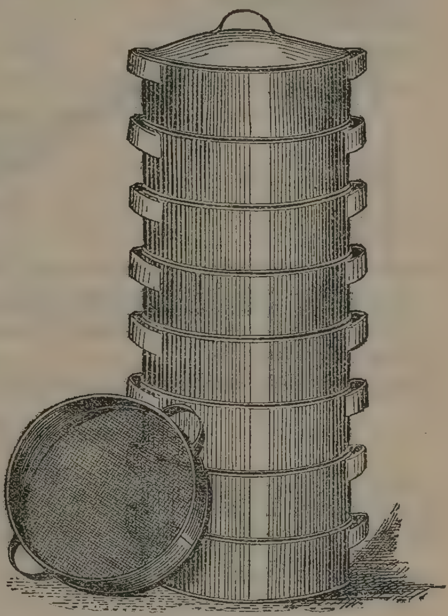

FIG. 89.—Set of sieves for cleaning seeds.

rately or together in any combination. The holes should be of different sizes and various patterns, as shown in figure 88. Such sieves can be obtained in this country at from 75 cents to $1 apiece.

SEED-CLEANING APPARATUS.

In addition to the set of sieves, a machine for cleaning seeds becomes useful. For this purpose a florist's counter mill, such as seedsmen often use, costing about $35, will be found advantageous. The general principles of seed-cleaning machines are shown in figure 90, which is a cross section of a fanning mill used in Germany. The seed is poured into the hopper *A*. Its delivery into the air chamber below is regulated by the slide *f*. The falling seed is struck by a current of air caused by the revolution of the fans *B*. This throws the lighter foreign materials, such as chaff and lumps of sand, out at the rear of the machine. The heavier seed strikes the front of the prismatic body *c*, which is fastened to the movable bottom *b b*, passes over a set of sieves, *D*, and out

at *E*. At *e* is an oblique frame, against which a lighter grade of seed strikes and falls below into the chamber *C*. By means of the screw *d* the bottom *b b* is moved backward or forward, thus regulating the sorting of the seed. The sorting is also influenced by the rate at which the fans are made to revolve; the faster the movement, the sharper will be the selection of first-class seed. Machines of this kind may be purchased for about $15. In Europe seeds are also sorted, according to their form, by machines called "trieurs," which need not be described in this place.

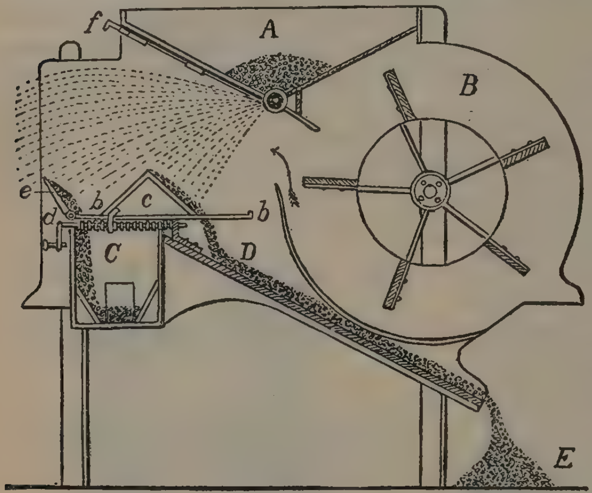

FIG. 90.—Diagram of seed-cleaning machine (after Settegast). *A*, hopper; *B*, fans; *C*, chamber for seeds of medium weight; *D*, sieves; *E*, good seed; *f*, hopper slide; *b b*, bottom of mill; *c e*, regulating slides; *d*, regulating screw.

SEED COLLECTION.

One of the principal features of the equipment should be a collection of seeds kept in glass bottles and systematically arranged. The identification of foreign seeds in the samples tested is impossible without such a collection.

The seed collection of the Division of Botany is put up in glass specimen tubes, without necks, and of two sizes, one 5 cm. long and 1.5 cm. in diameter, the other 10 cm. by 3 cm., the smaller of which is shown in figure 91. In addition to the seeds, one or two capsules of the dry fruits are inclosed whenever possible. Fleshy fruits of our native wild plants are kept in a preservative fluid of some kind. Seedlings of economic plants in various stages of germination are also kept in alcohol for reference and study. The bottles are placed in cloth-covered trays made of heavy binder's board. The trays for the smaller bottles hold 100 specimens. These are placed in a case, which is to contain also, so far as possible, herbarium specimens of the plants from which the seeds were taken. A card index to the collection is of great assistance in finding specimens.

FIG. 91.—Bottle used in the United States National Herbarium for small seeds. (Almost natural size.)

THE GRAIN SMUTS: THEIR CAUSES AND PREVENTION.

By Walter T. Swingle,

Assistant, Division of Vegetable Pathology, U. S. Department of Agriculture.

To the ordinary observer nothing could seem more unlike a definitely organized plant than the black, dusty mass filling the kernels of wheat or replacing an entire head of oats. Yet, as a matter of fact, the black dust is composed of thousands of germs of a minute parasitic plant. These germs, or spores, which have the same function as the seeds of higher plants, are blown about by the wind and lodge on the healthy kernels of the grain. When the kernel sprouts the spores adhering to it germinate and send a slender thread into the young plant. The slender threads of the parasite follow the growth of the plant, but their presence can scarcely be detected until the head begins to develop. The flower or grain is then filled by a mass of the threads, which absorb the nourishment intended for the grain and are soon converted into a mass of spores, again ready to fly about and infect next year's seed.

The enormous amount of damage caused by these parasites has attracted attention since the time of the Greeks and Romans, and the history of the study of smuts and of the discovery of remedies for them within the last eight years forms one of the most fascinating pages in the records of vegetable pathology.

In the few pages at command it is hoped to present in brief outline the present state of our knowledge of smuts, and to give some account of the latest and best methods of preventing their ravages.

There are two classes of smuts which attack our common cereals, viz, the stinking smuts, which destroy only the kernel, and which have a pronounced disagreeable odor, and the loose smuts, which destroy not only the kernel but also more or less of the chaff, and which are more dusty and loose. The stinking smuts occur on wheat only, while the loose smuts are found on wheat, oats, and barley. As the different smuts have to be treated differently, it is of advantage to the agriculturist to be able to recognize them readily. Wheat, for instance, is attacked by three species—two stinking smuts and one loose smut.

STINKING SMUTS OF WHEAT.

The two species[1] are very similar and can usually be distinguished only by the aid of a microscope. The smutted kernels (usually all in

[1] *Tilletia fœtens* (B. & C.) Schroeter (which is the more common in this country), with globose or oval, smooth spores, and *Tilletia tritici* (Bjerk.) Winter, having globose spores, with net-like ridges on the outer surface of the wall. Harwood states that wheat attacked by the latter species has shorter stalks than healthy grain, while that attacked by the former species grows as tall as unaffected wheat.

the head are affected) are slightly larger and more irregular in shape than healthy grains, and are easily broken open, disclosing a dark-brown powder, which possesses a disagreeable, penetrating odor. Even a small per cent of smutted kernels will give a whole bin of wheat this characteristic odor. The stinking smuts are thus easily recognized if present in any considerable quantity in the thrashed grain. This is not true of any other grain smuts, however. Figures 92 and 93 show the appearance of heads of wheat attacked by the stinking smuts.

FIG. 92.—Head of beardless wheat affected with smut.

FIG. 93.—Head of bearded wheat affected with smut.

These smuts occur more or less abundantly in all wheat-growing countries. They are widely distributed in the United States, though fortunately there are many regions where they are still unknown.

There are no accurate statistics as to the amount of damage caused by these smuts. In many localities the loss is very large, and it can not be doubted that in the whole United States it amounts to many millions of dollars annually. Sometimes 50 or even 75 per cent of the heads are smutted, and besides the sound grain is so contaminated with the fetid spores as to be nearly worthless for flour and worse than useless for seed. The disease is often spread from farm to farm by thrashing machines. When once introduced, if left unchecked, it increases year by year until a large percentage of the crop is destroyed. It can usually, however, be more or less held in check by some form of bluestone treatment of the seed, but the treatment very rarely gives

entire protection. Directions will be given at the close of this article for entirely preventing the smuts, no matter how bad they may have been in the crop used for seed.

LOOSE SMUT OF WHEAT.

This is very different from the stinking smuts.[1] It has no fetid odor; attacks both kernel and chaff; ripens when the healthy wheat is just flowering; and is composed of a loose, dusty mass of spores. These spores are usually entirely blown away by harvest time, leaving only the naked stalk where the head should be. Figure 94 shows the appearance of a head of wheat at flowering time which has been attacked by this smut, while figure 95 shows the appearance of another head at harvest time.

FIG. 94.—Head of wheat affected with loose smut in the lower half.

FIG. 95.—Head of wheat affected with loose smut—harvest time.

Loose smut is known to occur in Europe, North America, north Africa, central Asia, and the East Indies. It occurs in many parts of the United States, though fortunately it is rare or entirely absent in many localities. It does not usually destroy so large a proportion of the crop as do the stinking smuts; still, it often causes a loss of 10 per cent or more of the crop, and has even been reported as destroying over 50 per cent of a crop in Michigan. It may be present in considerable amount and yet be entirely overlooked, since the smutted heads are reduced to bare stalks at harvest time and there is no trace of it visible in the thrashed grain. The only way the agriculturist can be sure his crop is free from it is to examine carefully his fields when the wheat is flowering. The loose smut is to be feared, not so much on account of the great damage it causes, but because it is very difficult to prevent, and if once introduced into a field it is likely to remain year after year; for, as has long been known, the old bluestone treatments, though often very effective against stinking smuts, do not affect this species. It has also been shown by Kellerman and Arthur that the ordinary forms of hot-water treatment are not effective against it. From the experiments of Professor Kellerman and the writer, it can,

[1] *Ustilago tritici* (Pers.) Jensen. A variety of this smut, which attacks the leaves and sheaths as well as the heads, has recently been reported from Egypt.

however, be safely concluded that certain forms of the hot-water treatment are effective against loose smut, but injure the germinative power of the seed. Wheat growers should therefore be on their guard against this enemy, and try to secure seed wheat from fields known by careful examination at flowering time to be free from loose smut. It can, however, be combated by treating enough wheat to furnish seed for the following year, and this should be done when any considerable per cent of the crop is affected.

LOOSE SMUT OF OATS.[1]

This smut is very similar in general appearance to the loose smut of wheat, and like that species it ripens when the grain is in flower, and is blown about by the wind. At harvest time the head is often entirely bare. There is, however, a form[2] of this smut which destroys only the kernel and leaves the outer chaff unaffected. This is very hard to recognize, since the smutted heads look almost exactly like those of healthy plants, and can be detected only by cutting open the husks, when a mass of smut will be found in place of the kernel. Sometimes more than two-thirds of the smut is of this hidden form. This is likely to cause the grower to greatly underestimate the amount of smut.

The appearance of the ordinary form of oat smut at flowering time is shown in figures 96 and 97; its appearance at harvest time is shown in figure 98. The hidden smut can not be distinguished from a healthy head in an illustration.

This smut has probably the widest distribution of any of the thousands of species known to students of the group. It is known on every continent and occurs all over the United States. In fact it is an uncommon thing to find a field of oats entirely free from it, and the amount of damage it causes is very great. Not one in a thousand of those engaged in growing oats has any adequate idea of the extent of its ravages. Hundreds of examinations have been made in oat fields in various parts of the United States, and as a result we have very reliable estimates as to the amount of this smut in various localities. Estimates made by Professor Kellerman and the writer put the actual loss from oat smut in Kansas at $1,382,328 in 1888, $850,554 in 1889, and $911,299 in 1890; Dr. Arthur estimates the damage in Indiana at $797,526 in 1889 and $605,352 in 1890; Harwood estimates the damage in Michigan at $800,000 in 1891 and $1,000,000 in 1892. In these States the average amount of smutted heads varied from 6.5 per cent to 15 per cent. The only State where decidedly lower per cents of smutted oats have been reported is Vermont. Here Jones found an average of 1.6

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[1] *Ustilago avenæ* (Pers.) Jensen.

[2] *Ustilago avenæ, levis* Kell. and Swing. All hidden smuts belong to this variety, but not all *levis* is hidden smut. This variety seems to be what Wille has called *U. kölleri*. Jensen, however, infected oats with covered smut spores and obtained one-sixth completely naked smut.

per cent smutted in 1892. This would represent a loss of $26,454.[1] It is undoubtedly a conservative estimate to place the direct loss from oat smut at 8 per cent of the crop. Even at this estimate the loss in the United States is over $18,000,000 annually, averaging $18,504,140 for the

FIG. 96.—Head of oats affected with smut, but having the chaff only partially destroyed.

FIG. 97.—Head of oats affected with smut, having the chaff only partially destroyed; decidedly smutty.

Fig. 98.—Final stage of smut, showing condition of head at harvest time.

years 1890 to 1893[2]. This, however, though it represents the amount that would be saved if every smutted head of oats were replaced with

[1] Using the estimates of this Department, putting the value of the crop at $1,626,944 (see Annual Report of Secretary of Agriculture for 1892, p. 420).

[2] Using the estimates made by this Department, putting the average value of the oat crop for these years at $212,797,614 (see Annual Report of the Secretary of Agriculture for 1893, p. 483).

a sound one, does not by any means represent what would be saved by a universal system of seed treatment. It has been conclusively proved that a much greater increase in yield is obtained by treating the seed than would result from merely replacing the smutted heads with sound ones. This will be explained later.

It should be remembered that it costs as much for every farming operation to raise a badly smutted crop as a clean one. The smut does not thin out the stand and give the healthy plants more soil and better light; a smutted plant takes up as much room and requires as much moisture and nourishment from the soil as does a healthy plant. The loss by smut can therefore be said to be taken directly from the profit on the crop. Moreover, the seed from a badly smutted field is likely to produce a badly smutted crop the following year, while that from a clean field will produce a crop almost if not entirely free from smut.

By means of two newly discovered treatments of the seed, viz, with potassium sulphide, and with hot water, oat smut can be completely prevented at very little expense. The methods will be explained hereafter. Fortunately, both the common and hidden forms of smut can be eradicated with equal ease. It is certain that oat growers could save many millions of dollars annually above all expenses by treating their seed oats.

SMUTS OF BARLEY, RYE, AND CORN.

Barley is attacked by two loose smuts, both very similar to the loose smut of oats. In the covered barley smut[1] the spores are often retained till harvest by a thin membrane, inclosing the smutted kernel and chaff. The naked barley smut,[2] on the other hand, is like the ordinary form of oat smut, and is usually all blown away long before harvest. Both kinds of barley smuts can be completely prevented by the treatment recommended further on.

Rye smut[3] attacks the leaves and stems of this cereal, and sometimes weakens the plants considerably. Jensen thinks it can be prevented by treating five minutes with hot water at 127° F.

Corn smut[4] is of widespread occurrence, but rarely causes more than a fraction of 1 per cent loss. No method of prevention is as yet known.

PRACTICAL DIRECTIONS FOR TREATING SEED FOR SMUT.

POTASSIUM SULPHIDE TREATMENT FOR OAT SMUT.

The potassium sulphide should be of the fused form known as "liver of sulphur." It can be obtained of any druggist for from 25 to 50 cents per pound, depending on the quantity purchased. It should be kept

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[1] *Ustilago hordei* (Pers.) Kell. & Swing.
[2] *Ustilago nuda* (Jens.) Kell. & Swing.
[3] *Urocystis occulta* (Wallr.) Rabenh.
[4] *Ustilago maydis* (DC.) Cda.

in a tight glass vessel, protected from the air, until ready for use. Dissolve 1½ pounds in 25 gallons of water in a wooden vessel; a tight barrel is very good for the purpose. The lumps of potassium sulphide dissolve in a few minutes, making the liquid a clear yellowish-brown color. After thoroughly stirring, put in about 3 bushels of oats and agitate well to insure wetting every grain. The solution must completely cover the grain and be several inches above it, as the grain soaks up some of the liquid. Leave the oats in this solution twenty-four hours, stirring several times during the day to be sure every kernel is wetted. Then spread out to dry. In treating large quantities of seed, a hogshead or a wooden tank might be used. The solution should not be used more than three times. In no case should any metal be allowed to come in contact with the liquid. This treatment is thoroughly effective for oat smut, and is worthy of trial for stinking smut of wheat.

THE HOT-WATER TREATMENT FOR STINKING SMUT OF WHEAT AND OAT SMUT.

Provide two large vessels, preferably holding at least 20 gallons. Two wash kettles, soap kettles, wash boilers, tubs, or even barrels, will do. One of the vessels should contain warm water, say at 110° to 120° F., and the other scalding water, at 132° to 133° F. The first is for the purpose of warming the seed preparatory to dipping it into the second. Unless this precaution is taken it will be difficult to keep the water in the second vessel at the proper temperature. A pail of cold water should be at hand, and it is also necessary to have a kettle filled with boiling water from which to add from time to time to keep the temperature right. Where kettles are used a very small fire should be kept under the kettle of scalding water. The seed which is to be treated must be placed, half a bushel or more at a time, in a closed vessel that will allow free entrance and exit of water on all sides. For this purpose there can be used a bushel basket made of heavy wire, inside of which is spread wire netting, say 12 meshes to the inch; or an iron frame can be made at a trifling cost, over which the wire netting can be stretched. This will allow the water to pass freely and yet prevent the passage of the seed. A sack made of loosely woven material, as gunny sack, can be used instead of the wire basket. A perforated tin vessel is in some respects preferable to any of the above. In treating stinking smut of wheat, the grain should first be thrown into a vessel filled with cold water; then, after stirring well, skim off the smutted grains that float on top and put the grain into the basket or other vessel for treatment with hot water. This skimming is entirely unnecessary with other grains, and even with wheat when affected only by the loose smut. Now dip the basket of seed in the first vessel, containing water at 110° to 120° F.; after a moment lift it, and when the water has for the most part escaped plunge it into the water again, repeating the operation several times. The object of the lifting and plunging, to which

should be added also a rotary motion, is to bring every grain in contact with the hot water. Less than a minute is required for this preparatory treatment, after which plunge the basket of seed into the second vessel, containing water at 132° to 133° F. If the thermometer indicates that the temperature of the water is falling, pour in hot water from the kettle of boiling water until the right degree is attained. If the temperature should rise higher than 133°, add a little cold water. In all cases the water should be well stirred whenever any of a different temperature is added. The basket of seed should very shortly after its immersion be lifted and drained, and then plunged and agitated in the manner described above. This operation should be repeated six or eight times during the immersion, which should be continued ten minutes. In this way every portion of the seed will be subjected to the action of the scalding water. In practice it will be found best to have a man

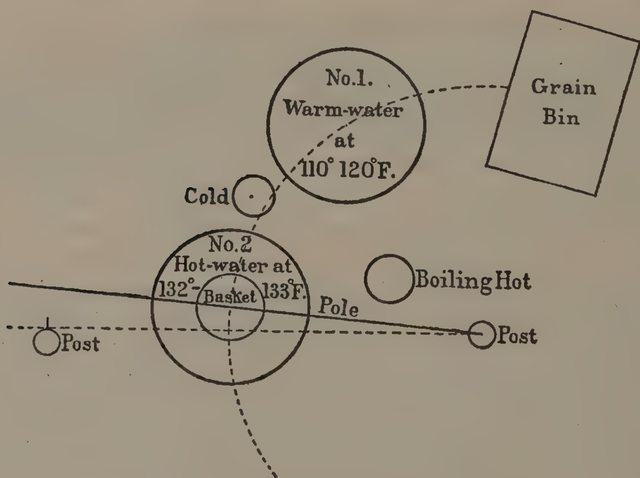

FIG. 99.—Diagram showing arrangement for treating smut.

or boy devote his whole time to keeping the temperature at the right point, adding a little hot water if it falls below 132° and a little cold if it gets above 133° F.[1] Another man should handle the grain and immerse and drain the portion being treated as directed above. After removing the grain from the scalding water, spread on a clean floor or piece of canvas to dry. The layer of grain should not be over 3 inches thick. If it can not be spread out at once, dip in cold water and set to one side until it can be attended to. It dries better if spread while still hot. Another portion of grain can then be treated, and so on until all the seed has been disinfected. Directions for drying the seed will be given further on.

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[1]A good thermometer should be used, preferably one having the bulb protected against injury from striking the sides of the vessel. The large thermometer used in dairy work is very good for this purpose.

The important precautions to be taken are as follows: (1) Maintain the proper temperature of the water (132° or 133° F.), in no case allowing it to rise higher than 135° or fall below 130°; (2) see that the volume of scalding water is much greater (at least six or eight times) than that of the seed treated at any one time; (3) never fill the basket or sack containing the seed entirely full, but always leave room for the grain to move about freely; (4) leave the seed in the second vessel of water ten minutes.

When steam is available, it can be conducted into the second vessel (containing the scalding water) by a pipe provided with a stopcock, and this answers better than any other method for heating the water and for elevating the temperature from time to time. A good arrangement for hot-water treatment is shown in figure 99.

A pole is provided having a large hole at one end, which passes over a small peg in the top of the first post. This should allow the pole to move both up and down and sidewise. By swinging the pole around the basket can be filled at the bin, then immersed a moment in vessel No. 1, and then swung over to vessel No. 2, where the grain is treated ten minutes. Every minute or so the basket must be raised entirely out of the water and allowed to drain. The pole can be supported on a peg or fork in the second post while the basket is draining. Finally, the pole is lifted entirely over the second post and the grain is spread out to dry. Of course this arrangement is necessary only when large amounts of seed are to be treated. For small amounts a tub of warm water and a common wash boiler on a cook stove for the scalding water will answer every purpose.

There are many possible modifications of the hot-water treatment that are more easily used than the one here given, but whenever they have been tested on a large scale they have proven uniformly less successful in preventing smut than the method here given, and do not give as great an increase in yield. They are, moreover, not nearly as convenient as the potassium sulphide or bluestone and lime methods.

HOT-WATER TREATMENT FOR LOOSE SMUT OF WHEAT AND FOR BARLEY SMUTS.

In treating wheat for loose smut, the grain must be soaked four hours in cold water, then set away about four hours more in wet sacks, and finally treated as directed above, but only for five minutes, at 132° F. In planting, use one-half more seed per acre to compensate for the seed killed by the treatment. For preventing both of the smuts affecting barley the grain should be soaked as directed above and treated five minutes at 130° F., 2° lower than for wheat.

COPPER-SULPHATE TREATMENT FOR STINKING SMUT OF WHEAT.

This consists in immersing the seed wheat twelve hours in a solution made by dissolving 1 pound of commercial copper sulphate in 24 gallons of water, and then putting the seed for five or ten minutes into

limewater made by slaking 1 pound of good lime in 10 gallons of water. The treatment is cheap, easily applied, and very effective. The wheat does not grow quite so well as when treated with hot water, but the difference is inconsiderable. This treatment is only for stinking smuts of wheat and covered barley smut. It should never be used for oat smut.

DRYING THE TREATED SEED.

All of the seed treatments leave the seed wet and necessitate drying before planting. The grain should be spread in a layer 2 or 3 inches deep, and should be shoveled over twice or three times a day. It will then dry very quickly. A clean floor is a good place to dry the grain, but a better method is to take canvas sheets about 5 feet by 12 or 15 feet and spread out in the sun. Such sheets, with the grain, can be taken in at night. If spread over an open lattice work a few feet from the ground, drying is greatly facilitated. Such sheets, of the heaviest ducking, should not cost over $1.75 each, and can be used for years. The grain can be sown broadcast long before it is thoroughly dry, but for drilling it must be nearly dry. The seed can be treated months before being used, and dried and stored ready for planting. In case of the stinking smut of wheat there is danger of the seed being reinfected by contact with living spores, though with other smuts the danger is almost absent. In treating wheat against this smut, tools and sacks should be disinfected, and if a floor is used for drying, it should first be washed with a solution of bluestone (1 pound to 10 gallons of water) before spreading the grain. Canvas sheets and sacks can be disinfected easily by plunging into boiling water.

EXTRA INCREASE IN YIELD AS A RESULT OF SEED TREATMENT.

One of the most remarkable and unexpected results of the hot-water and potassium-sulphide seed treatments was an increase in the yield beyond the amount that would result from merely replacing every smutted head with a sound one. This extra increase was first noticed by Professor Kellerman and the writer in experiments made with oats in 1889, where the hot-water treatment gave an increase in yield more than twice as great as would be calculated from the per cent of smut in adjoining untreated plats. This remarkable result was obtained in all subsequent trials, and was noted also by Jensen and Dr. Arthur. In the various experiments of the investigators named the extra increase in yield ranged from one-half to six times the amount to be expected from replacing the smutted heads with sound ones, and even higher ratios when the percentage of smut has been small. On an average the increase in yield has been double or treble what would result from suppressing the visible smut. In consequence of this remarkable benefit, comparable with what Mr. Galloway has shown to occur in using Bordeaux mixture on the potato and some other plants, it will

undoubtedly be profitable to treat oats for seed when only 1 or 2 per cent is smutted.

Potassium-sulphide treatment has given uniformly a large extra increase in yield when used in treating oats for seed. The extra increase has been very decided, almost equal to that resulting from treatment of seed with hot water. The copper-sulphate and lime treatment gives no extra increase whatever with oats.

Jensen has found a similar extra increase to result from treating seed barley with hot water, and Professor Kellerman has reported extra increase in yield in treating wheat for stinking smuts with hot water and also with several copper compounds. There was, however, an enormous amount of smut present in many of the untreated plats, reaching 75 to 80 per cent. Where there is only a small per cent of smut in the untreated wheat it is probable that little if any extra increase in yield would result from treating the seed.

As to the cause of the extra increase in yield as a result of seed treatment opinions are divided. It is probably due in part to an increased germinative power of the seed, causing them to sprout sooner and the young plant to grow faster. It has been shown that oats treated with hot water germinate much more quickly than do untreated oats, even if the grain has been dried. Professor Kellerman has shown that potassium sulphide has the same effect on both oats and corn, and further that, even after five and one-half months, seed which had been treated with hot water or potassium sulphide germinated quicker than untreated seed. Dr. Arthur claims that this hastened germination is due to the liberation at once of large quantities of diastase by the action of heat, enabling the young plant to avail itself rapidly of the reserve of starch stored in the seed. This does not, however, account for the action of potassium sulphide. Another possible explanation of the observed extra increase in yield has been put forth by Jensen. He suggests that the smut may attack many plants, which it simply weakens and stunts, without ever developing its spores in the head. Such injury would of course be prevented by any treatment that killed all the smut adhering to the grain. It is highly probable that a part of the extra increase is due to the higher germinative energy of treated seed and a part to the prevention of all injury, however slight, from the smut.

DUTY OF SEEDSMEN.

It is confidently believed that by the aid of these improved methods of seed treatment the enormous losses from the grain smuts will eventually be prevented in a great measure. Every year more growers treat the grain intended for planting, and others often profit by purchasing clean seed from the resulting crop for use the following year.

It is to be hoped that all reputable seed firms will treat the grain they sell for seed. Oats purchased at high prices for seed have been known to yield crops more than half smutted. In Kansas in 1890 Professor Kellerman and the writer found that nearly one-fourth of the

sorts of oats grown from seed obtained from dealers was badly smutted, one-fifth showing over 11 per cent of injury, and one-tenth over 20 per cent. The danger exists in even greater degree with other cereals, for the wheat smuts, for instance, do not occur at all in some regions and can readily be brought in by obtaining seed from infested fields.

SUMMARY.

(1) Smuts of cereals are caused by minute parasitic fungi, the spores of seeds of which form the black, dusty mass which replaces the head or kernels of grain.

(2) These spores are very minute and blow about and adhere to the kernel before it is planted. When the kernel sprouts the spores also germinate and send delicate threads into the young seedling. These threads follow the growth of the plant and fill the head or kernel as soon as formed, and there develop a mass of spores instead of kernels.

(3) Two stinking smuts attack the kernels of wheat, filling them with a mass of fetid spores. These smuts cause great damage, but are easily prevented by treating the seed wheat.

(4) Loose smut of wheat attacks the whole head and converts it into a mass of loose and dusty spores. It causes considerable damage in some localities and is more difficult to prevent than other smuts.

(5) Loose smut of oats is very similar to that of wheat. It causes over $18,000,000 loss annually in the United States. It can be prevented easily and cheaply.

(6) Barley is attacked by two smuts and rye by one, all of which can be prevented. Corn smut is widespread, but fortunately causes only a very slight loss. As yet no effective preventive is known.

(7) Oat smut can be most easily prevented by soaking the seed twenty-four hours in a 1 per cent solution of potassium sulphide.

(8) Stinking smut of wheat and oat smut can be easily prevented by treating with hot water at 132° F. for ten minutes. By previously soaking the seed in cold water, loose smut of wheat, barley smuts, and rye smuts can be prevented by a shorter immersion in hot water.

(9) Stinking smuts of wheat can be prevented by soaking the seed twelve hours in a 1 per cent solution of copper sulphate and then dipping the seed in limewater. This treatment is useless for other smuts.

(10) In treating oats for smut by either potassium sulphide or hot water, an increase in yield is obtained beyond and above the amount that would result from replacing the smutted heads with sound ones. The increase in yield from seed treatment is usually two or three times as much as the apparent loss from smut in untreated fields.

(11) Seed dealers should treat all cereals offered for sale, both to increase the yield and to prevent the introduction of smuts into localities where they are now unknown.

GRASSES AS SAND AND SOIL BINDERS.

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It is stated in the annals of creation that the first vegetation called forth upon the face of the earth, after the separation of land from water, was grass, and this, as appears now, was for the immediate purpose of binding the soil together and protecting it from the action of the winds and waves, which combined to destroy it. The force of this idea is best appreciated by those who live upon our coasts, where the constant working of tides and waves, increased at times by furious gales, is ever a menace to their lands and dwellings. A never-ceasing battle is being waged between water and land, the former having the wind for its strongest ally. The digging out and undermining by swift currents, the constant beating of the waves upon lake and ocean shores, and the perpetual shifting about of vast quantities of loose sands by the force of the winds cost our country many millions of dollars annually. Valuable tracts of land are buried beneath worthless sands, or possibly are washed out to sea; harbors are rendered unsafe or are entirely obstructed, and important channels of commerce are closed. These are some of the important effects of the action of the winds and waves in their battle with the land, which occasion the annual enactment of a "river and harbor bill."

Those living by the seashore have seen these destroying forces held in check by humble grasses whose stems bend to the elements like the fabled reed, but whose deep and widely penetrating roots bind the sands together in a network of strong fibers, defying the encroachment of the waves upon their domain.

These sand-binding grasses are in nature the allies of the earth in its battles with the warring elements, and may be made the direct allies of man in his efforts to protect his interests in the land. With their aid it has been possible for Holland to defy the waters of the North Sea and hold the lands so laboriously wrested from it. Other nations, by their aid, have been enabled to maintain valuable harbors or to preserve for the farmer large and fertile areas for tillage. In less enlightened times than ours, laws have been enacted for the careful preservation of the more important of these grasses. The wisdom of such laws was never more manifest than it is to-day, and their enactment may be said to be scarcely less important than those designed for the preservation of our forests. Such a law might well be incorporated in, or made supplementary to the river and harbor bill.

FIG. 100.—Marram grass on the sand dunes near the mouth of the Kalamazoo River, Michigan.

The great labor and expense involved in clearing river channels, maintaining levees, and protecting our harbors could in a short time be very much reduced by the intelligent planting of sand or soil binding grasses and securing their preservation from wanton destruction. The many inquiries for information which have been addressed to the United States Department of Agriculture relative to sand-binding grasses and those adapted to holding embankments of railroads, canals, etc., clearly indicate the importance of the subject, and that it possesses more than a local interest.

All sand or soil binding grasses have strong creeping rootstocks, or rhizomes, often familiarly called "roots," which are really modified underground stems. The true roots of grasses are always fibrous, but these are generally produced in great abundance, and when very long, as they often are, their effect in binding the soil is also important. A distinction may be made between sand binders and soil binders; the latter, growing on loamy or clayey soils, form a compact turf. With these may be classed the mud binders—the grasses of the bogs and those of the muddy shores of lakes and rivers. Of the true sand binders there are two forms—first, the larger and coarser sorts, which are exposed to the most severe action of the waves or winds, having their rhizomes deeply buried in the sands, these sending up leaf-bearing and flower-bearing branches, which appear in larger or smaller scattered tufts (see fig. 100); and, second, those whose prostrate stems creep over the surface of the sands, emitting at frequent intervals long, fibrous roots. The grasses of the first class are of little or no value for forage; those of the second class form close, leafy mats over the surface of the ground, and usually possess considerable value for grazing or for lawns on very sandy soil.

FIG. 101.—Marram grass (*Ammophila arenaria*).

DISTRIBUTION OF SAND-BINDING GRASSES.

It is interesting to note the distribution of sand-binding grasses. The fact is well known that the different species of animals and plants occupy different areas of the earth's surface, some being limited to the region of the tropics, others to the temperate regions, and others still to the confines of the frigid zones; some exist only in the Old World, others only in the New; some are limited to the northern hemisphere,

others appear only in the southern. Changes of latitude bring about a change in the species, and the plants of the coastal regions are often quite different from those of the interior. Very few species are cosmopolitan. With plants there are in addition soil limitations; some grow only in sands or sandy soil, others in marls or clays or loams; some where the soil is very dry, others where it is wet. There are very few strictly aquatic grasses.

To the far north, on the Atlantic coast, sea lyme grass is the most prominent sand binder. Below the region occupied by this grass, which does not extend south of Maine, marram is the leading species. This in turn gives way, south of Maryland, to bitter panic grass, which extends to Florida and around some parts of the Gulf coast. There are several important sand binders among the littoral grasses along our southern borders, and among them may be mentioned St. Augustine grass and creeping panic. The ocean shores of other countries have their peculiar sand-binding grasses, two of which are described below. Some of these foreign sorts may be introduced into this country to advantage; for special purposes or locations they might prove to be superior to our native species.

FIG. 102.—Upright sea lyme grass (*Elymus arenarius*).

In the interior regions, away from the influence of salt water, the sand binders are usually represented by other but no less valuable species. The long-leafed sand grass, extending from the shores of the Great Lakes westward to the Rocky Mountains, and Redfield's grass are the principal sand binders of this region, although marram grass and the sea lyme grass are found to a limited extent along the borders of Lakes Michigan and Superior. Our grasses have been little studied in the line of the present subject, particularly in the arid regions of the Southwest and along the Pacific coast. Doubtless, species occur in these sections quite as valuable as any of those already named. In strictly alkaline soils, alkali grass is a very strong sand binder, and may be as useful in reclaiming these lands as is the usar grass in northern India. Fine-top salt grass, which is more common in Arizona and New Mexico, affects similar soils, and may be even more valuable. There are also several species of *Muhlenbergia* which ought to receive attention in this connection, notably *Muhlenbergia pungens*. Running mesquit and several species of *Bouteloua*, or grama grasses, are valuable sand and soil

binders of the mesas of Arizona and western Texas. These last are useful also for pasturage. Along the Gulf coast of Texas and the shores of southern California "salt cedar" is doubtless a good sand binder, and the curious diœcious *Jouvea*, a grass similar in habit to alkali grass, and growing naturally along the sandy coasts of Lower California, is evidently an important grass to be considered in this connection.

The propagation of sand-binding grasses may be effected by seed when this can be procured, but the better way in most cases is to collect and transplant cuttings of the creeping rhizomes. These are not difficult to obtain, and a comparatively small amount will serve to cover a considerable area, for they may be cut up into single joints, and every joint will serve to establish a new plant. This method is applicable to turf formers, also used to hold embankments, such as couch grass, Hungarian brome, Johnson grass, and Bermuda grass.

FIG. 103.—Rolling spinifex (*Spinifex hirsutus*).

As already stated, the question of the importance of grasses as sand binders has up to this time received very little attention, excepting in one or two cases, and in the present paper it is hardly possible to do more than call attention to its real interest and importance, and briefly note some of the grasses already known to be or most likely to prove useful as sand and soil binders.

THE SAND BINDERS OF THE SEASHORE.

The best known and one of the most important of all sand binders is *marram grass*, or sand reed (fig. 101). The stout, long-leafed, coarse stems which spring from extensively creeping rootstocks usually grow

in tufts (see fig. 100). They are 2 to 4 feet high and the stems are solid, a character rather uncommon among grasses. As the sands drift in around the plants new branches are formed in the lower leaf axils, so that the stems appear to rise up with the increasing depth of the sands. The densely flowered panicle is from 3 to 6 inches long (fig. 101, *b*), and usually pale straw colored. The strong rootstocks of marram grass often grow to the length of 20 or 30 feet, and finally become closely interwoven, forming a dense, mat-like mass, very resistant to the action of the waves and winds.

FIG. 101.—St. Augustine grass (*Stenotaphrum americanum*).

This grass is common all along the coast of northern and western Europe, and on our Atlantic coast from Virginia northward. Below its southern limit grasses of other kinds take its place. It is not confined to salt-water regions, for it grows in considerable abundance along the shores of the Great Lakes. It is of comparatively little value for hay or pasturage, but for binding the loose and drifting sands of the sea or lake shores, or for resisting the action of the waves, it probably has no superior in the region over which it extends.

For the purposes just named the value of marram grass has been recognized for many years. In the time of William III an act of Parliament was passed to preserve this species and the sea lyme grass, described below, along the Scottish coast, and laws were subsequently made, both in England and in Holland, prescribing penalties for the wanton destruction of these grasses; even the possession of any of the stalks within 8 miles of the coast was treated as a penal offense. Many years ago it was as customary every spring to warn the inhabitants of Truro and some other towns on Cape Cod, Mass., to turn out to plant marram grass as it was in the inland towns to turn out and mend the roads. This was required by law, with suitable penalties for its neglect, and took place in April.

Marram grass has been introduced along the Pacific coast, near San Francisco, for the purpose of binding the sand dunes there; and, as an illustration of how valuable a thing may seem if it is far enough removed from us, the seed for the cultivation of this grass at the point mentioned was obtained from Australia. From the fact that the plant grows along the Great Lakes, it is evident that it is as valuable for fresh-water shores as for the seashore. An English writer states that it will grow very well on sandy clay soil, far removed from the coast, and hence it is very likely to prove valuable for keeping together railroad embankments or the banks of canals, ditches, etc., where fodder grasses are not desired, or where a green and close turf is no object. This grass may be propagated by seed, but more rapidly and certainly by root cuttings, which are not difficult to procure, and which are easily planted in localities where it is desired to introduce it. These cuttings are planted in rows 6 feet apart and 2 feet distant in the rows, being buried from 12 to 15 inches in the sand. The seed is occasionally offered for sale by our leading seedsmen.

FIG. 105.—Louisiana grass (*Paspalum compressum*).

The strong roots are capable of being made into ropes, and on some parts of the English and European coasts they are woven into coarse mats, while the stems are used for thatch. The stems and leaves have been used for making a kind of coarse paper.

"In the latter part of the last century," says Sowerby, "a large district on the western side of Scotland, near the Moray firth, was completely destroyed, and rendered in a few years as desolate as the Sahara, by the advance of the sand from the shore, owing to the wanton destruction of the marram that grew upon it."

In contrast with this, the town and harbor of Provincetown, once called Cape Cod, one of the largest and most important harbors of the United States, owe their preservation to this grass. At one time Provincetown had a "beach-grass committee," whose duty it was to enter

any man's inclosure, summer or winter, and set out marram,[1] or beach grass, as it was called, if the sand was uncovered or movable. Sandstorms, once the terror of the town, were thus entirely prevented.

Hardly less important than marram as a sand binder is the upright *sea lyme grass* (fig. 102). This grass has stout, smooth culms, 3 to 6 feet high, and long, sharp-pointed, rigid leaves. The pubescent and usually three-flowered spikelets are an inch long and disposed in a narrow spike, 6 to 12 inches long (fig. 102, *b*). In habit of growth and general appearance this lyme grass has a striking resemblance to marram. The leaves are shorter and broader at the base, the spikelets are more than one-flowered and downy upon the outside, while in marram the spikelets are smooth and always one-flowered.

FIG. 106.—Coast couch grass (*Zoysia pungens*).

The upright lyme grass is common all along the coasts of northern Europe and the British Islands, and on our western coast as far south as Oregon. A closely related species, having similar characters and habit of growth, occurs on the Atlantic coast from Maine northward, and on the shores of Lake Superior.

The upright lyme grass and marram are often found growing together. Sinclair, in referring to this fact, states that the sand hills near Skegness, Lincolnshire, England, "were formed by the sea lyme grass and marram; the latter, with its tufty habit of growth, formed the summit of the hill, while the broad-spreading roots and leaves of the lyme grass secured the base and sides. These two grasses, when combined, seem admirably adapted by nature for the purpose of forming a barrier to the encroach-

[1] The name "marram," or "murram," applied to this grass, is supposed to be derived from the Gaelic muram, or the Danish marhalm, meaning sea straw. In Denmark the name "marehalm" is applied to *Elymus arenarius*, "klittag" being the common name of *Ammophila arenaria*.

ment of the sea. What sand the marram arrests and collects about itself the lyme grass secures and keeps fast."

The cultivation of upright lyme grass for the purpose of binding loose sands by its creeping roots was practiced more than a hundred years ago, as mentioned by Schreber in his great work on grasses. Under ordinary conditions this grass possesses no value as a forage plant. The Digger Indians of the Northwest use the seeds for food, and, as it springs up around deserted lodges, it is called by the inhabitants "rancheria grass."

South of the range of marram grass, on our Atlantic coast, *bitter panic grass* may be utilized as a sand binder. It grows in sands along the seashore from Connecticut southward, and along portions of the Gulf coast. Near its northern limit it appears only in a reduced form, scarcely more than a foot high, with narrow, few-flowered panicles. Along the coast of the Carolinas it becomes larger, attaining a height of from 2 to 5 feet, and has large, many-flowered panicles, and in general appearance closely resembles forms of switch grass, presently to be noted. The stems are coarse and hard, sometimes half an inch in diameter at the base; the leaves are firm in texture, very bitter to the taste, and, with the sheaths, are pale green, glaucous, or sometimes straw-colored. The spikelets are larger than those of switch grass. The strong, spreading rootstocks are effectual in holding the loose sands of the coast, to which this grass appears to be confined. Elliott, who first described bitter panic in his Botany of South Carolina and Georgia, states that it grows among the sand hills on the seashore. It is abundant on the islands south of Mississippi Sound. These islands, according to Prof. S. M. Tracy, are almost wholly made up of drift sands, the outer sides being dunes from 10 to 30 feet high, while the middle of the island is usually occupied by swamps or lakes. This panic is most abundant on the

FIG. 107.—Long-leafed sand grass (*Calamovilfa longifolia*).

outside of the dunes, where it is exposed to the winds and waves, and where it certainly serves well for binding the sand.

Switch grass, a species closely allied to bitter panic, often grows along the coast, and is of considerable value as a sand binder. It has powerful creeping rootstocks, and is easily propagated, either by seed or by root cuttings.

A conspicuous grass of our southern shores, and belonging to the class of sand binders, is *water oats*, or *beach grass*. This grass grows in the drifting sands along the seashore from Virginia to Florida, and along the Gulf coast westward to Texas. It has a stout upright stem, 3 to 5 feet high, very long, rigid leaves, and showy, nodding panicles of broad, whitish spikelets. The habit and general characters of beach grass indicate qualities of a first-class sand binder for the coast of the Southern and Gulf States. The large panicles are gathered for dry bouquets, and are often seen in our markets along with the plumes of pampas grass.

FIG. 108.—Redfield's grass (*Redfieldia flexuosa*).

On the coasts of southern California there is a beach grass (*Uniola condensata*) very closely allied to that above described. It is similar in habit, but the spikelets are smaller and more crowded in the narrower panicles.

Another species of Uniola (*Uniola latifolia*) is common in the Middle and Southern States away from the seashore. This, aside from being a highly ornamental grass in cultivation, is valuable for binding the banks of streams and rivers, or embankments which are not too dry.

A grass of lesser growth than those above described, but one of much value as a sand and soil binder, is salt grass, or alkali grass, as it is called in the interior. It is a common grass along our Atlantic and Pacific coasts, and in the deserts and alkaline soils of our Western States and Territories. The leafy culms, which vary from 6 to 18 inches in height, spring from tough, scaly rootstocks. The leaves are unusually

rigid and the stems are hard and wiry, so that the grass has very little value as a forage plant. The straw-colored spikelets are united into a rather small and unusually compact panicle or head. This grass can be recommended for binding loose sands and embankments near the seashore or in the alkaline regions of the interior. It should be rigidly excluded from arable lands, for it is hard to eradicate when once established, and the matted rootstocks form a sod that is exceedingly difficult to break with a plow.

In referring to this grass, in his Botany of the Death Valley Expedition, Mr. Coville says:

> Of all the plants that grow on moist soil in the desert, salt grass is the most abundant. In seizing upon new moist ground, it sends out long, straight rootstocks, often several yards in length, and from these, at intervals of about 4 inches, erect stems arise. A piece of ground thus taken presents, for the first few years, the striking appearance of being cut into triangles, quadrangles, and other similar geometrical figures. These rootstocks subsequently die and decompose between the nodes, and a large number of individuals are thus separated, forming new centers of growth, and soon covering the ground with a dense sod.

FIG. 109.—Bermuda grass (*Cynodon Dactylon*).

A notable sand binder is the *rolling spinifex* (fig. 103), common to the sandy coasts of Australia, Tasmania, and New Zealand. The hard, creeping stems, which root at every joint, give rise to coarse, upright, leafy tufts. The rather rigid and sharp-pointed leaves are often over a foot in length, and are clothed, as is the entire plant, with soft hairs. The male and female flowers of this grass are borne on separate plants, the latter in globular heads, several inches in diameter (see fig. 103, *b*). These heads are composed of numerous spine-like branches, each branch bearing at its base a single female spikelet (fig. 103, *b′*). The heads, which are often gathered for dry bouquets, fall off at maturity, and are driven over the sands by the winds, dropping their seeds as they roll along, or carried about by the waves and landed on newly formed sandbars, there to continue the embanking process.

Rolling spinifex is of no value as a forage plant, but in New South Wales it is regarded as a most useful grass for fixing drift sand when encroaching on valuable lands. It is easily propagated by cuttings or joints of the stem, is of comparatively quick growth, and is very persistent when once established. It would doubtless be of some value upon our southern coasts.

The *long-leafed spinifex*, a grass closely resembling the above, but quite smooth, grows on the sandy shores of north and west Australia, in some places covering the whole coast. This grass has many characters in common with *Spinifex squarrosus*, a species widely spread along the sandy seashores of southern Asia.

FIG. 110.—Fresh-water cord grass (*Spartina cynosuroides*).

Among the several grasses which act as sand binders by covering the surface of the sands with extensively creeping and branching stems, few, if any, are more effective than *St. Augustine grass* (fig. 104). This grass has a wide distribution, being found in the tropical and warmer temperate regions of both the Old and New World. In New South Wales it is known as buffalo grass, and in Jamaica it is called pimento grass. It grows upon every variety of soil, from the apparently sterile sand dunes to heavy clays, but never far away from the coast. The flattened stems emit fibrous roots at every joint, where they also readily separate, each piece becoming a new center of growth. The leaves are flat or simply folded, blunt or obtuse at the apex, usually about one-quarter of an inch broad, and from 4 to 10 inches long. The flowering stems grow to the height of from 6 inches to a foot or more, and the small spikelets are partially embedded in the flattened terminal and lateral spikes. (See fig. 104, *a*.)

St. Augustine grass grows along our ocean shores as far north as South Carolina, and is largely used as a lawn grass in Charleston, S. C., and cities to the south near the coast. It is propagated by cuttings or

sets, and quickly covers the most sandy yards with a dense carpet of perennial verdure. In South America the creeping stems are employed in medicine as a diuretic, as are the stems and rhizomes of couch grass in the United States.

Louisiana grass (fig. 105) in its habit of growth and foliage closely resembles St. Augustine grass, but it requires a richer and somewhat moist soil; nor is it confined to the seashore. The creeping, leafy stems cover the surface of the ground with a dense, matted growth, and the grass is not only valuable for grazing, but may be utilized in the Gulf States for lawns or to cover lands or embankments subject to wash.

Creeping panic is another widely distributed maritime grass belonging to this class of sand binders. The prostrate, creeping, and rooting stems cover the surface of the sand dunes along the Gulf coast, protecting them from the action of the winds and waves quite as effectively as the more deeply rooted bitter panic, which is occasionally found associated with it.

A well-known grass of the Old World, common on the maritime sands of tropical and eastern Asia, Australia, and New Zealand, is the little *coast couch grass* or *Japanese lawn grass* (fig. 106). This is highly spoken of as a sand binder by Australian writers. The extensively creeping rhizomes make a perfect network of strong fibers, effectively binding the drifting sands of the coast. It is one of the few grasses which are at the same time good binders of sands and excellent forage plants. Under favorable circumstances it forms a very compact turf, and affords a large amount of choice pasturage. It is highly commended as a lawn grass for sandy soils. This, or a very closely allied species from Korea, has been successfully grown in Connecticut, and doubtless it would make a lawn grass for our Southern cities near the coast superior to the rather coarse St. Augustine grass mentioned above. Mr. John M. B. Sill, consul-general at Seoul, Korea, who has furnished the United States Department of Agriculture with seeds of this grass, says that it makes a very firm, close, durable sod, and is highly prized in the foreign settlements in Japan and China. It sends out runners which soon cover a lawn with a soft, firm carpet that is especially prized for tennis courts. Constant cropping seems to improve this little grass and increase the density of the turf. It may be propagated by seed, but more easily and certainly by its "roots," the close, matted, wiry fibers forming a coherent mass, which is easily transported to a distance without injury, when it can be cut up and the pieces planted in the usual way.

INLAND SAND BINDERS.

The principal sand binders of the interior of our country, ranking with marram and the sea lyme grass, are the *long-leafed sand grass* (fig. 107) and *Redfield's grass* (fig. 108). In the sand dunes along the

borders of Lake Michigan the long-leafed sand grass grows in company with marram grass, which it fully equals as a binder of the drifting sands of the lake shore. This grass extends from Illinois westward to the Rocky Mountains, and southward to Kansas. Along the Missouri River it often covers considerable areas, affording protection to the sandy banks in times of flood; and in Nebraska it is one of the most characteristic grasses of the sand-hills region, growing in the "blowouts," where, with Redfield's grass, it does valuable service in binding the drifting sands. It has far-reaching, scaly rootstocks; stout stems, 2 to 6 feet high, and numerous rather rigid leaves, 1 to 3 feet long. The one-flowered spikelets (fig. 107, *a*) are in loose and more or less spreading panicles.

Redfield's grass appears to be limited to the more sandy regions west of the Mississippi River and east of the Rocky Mountains, extending from Nebraska southward to Arkansas. It is a characteristic grass of the sand hills of central Nebraska, growing in the drifting sands and "blowouts," and is a conspicuous and almost the only grass found on the sand dunes south of the Arkansas River, near Garden City, Kans. The hard, smooth, and long-leafed stems of Redfield's grass grow in tufts or bunches 2 to 4 feet high. The spikelets (fig. 108, *a*) are in ample, spreading, capillary panicles, which are often half the length of the stem. The rootstocks are strong and persistent, and the grass is recommended for propagation in the interior regions where sand binders may be desired.

For holding the muddy banks of rivers and streams several native grasses may be employed. They grow naturally in such situations, and are often of considerable value for hay. *Reed canary grass* is one of these. It is a stout, leafy grass, 2 to 4 feet high, with a narrow, densely flowered panicle. *Indian reed* is particularly useful for the purpose in question. It is a strong-growing species, 3 to 7 feet high, with a large panicle, 6 to 12 inches long. *Knot-root grass* is very common along river banks, usually where the soil is somewhat sandy, and by its abundant creeping rhizomes does good service in preventing the land from being washed away by strong currents or overflows. It has branching, leafy stems, which make good hay. *Common reed* (*Phragmites*) is regarded as one of the most valuable grasses for binding the banks of rivers subject to periodical floods. It has been called one of nature's most valuable colonists, from its usefulness in the conversion of swamps and stagnant pools into dry land. It grows along rivers and margins of lakes from Maine to California. It has extensively creeping rootstocks and stout, upright culms, 5 to 12 feet high, being one of the largest of our native grasses. Branches from the base of the culm are sometimes found creeping along the surface of the ground for a distance of 30 feet or more, and sending up leafy shoots at every joint. The rootstocks are very strong, and when the grass is once established, scarcely anything can move them. The young shoots are liked by cattle, and

the mature stems make the best thatch. This grass closely resembles the cultivated reed, and, like that species, is occasionally grown for ornament.

Swamp millet, an Australian grass, is highly spoken of as a pasture grass for wet lands. It has slender, creeping stems, and is classed with the species valuable for binding the banks of rivers or dams or any loose earth. In the same class, and valuable for like purposes, is a grass known in Australia as *southern wheat grass*. This is an erect species, growing from 2 to 3 feet high.

"*Blady grass*," common throughout the warmer temperate and tropical regions of the world, is a valuable sand and soil binder, and in warm countries is recommended for binding river banks, the sides of dams, and also the loose sands of the coast. The rootstocks form a perfect network of strong fibers, most difficult to eradicate. It is a rigid, erect species, from 1 to 3 feet high, and is easily recognized by its silvery-white, spike-like panicles, from 3 to 6 inches long. It is readily propagated by root cuttings, and might be utilized along the Gulf coast and in southern and western Texas, Arizona, etc. A native species of "blady grass" (*Imperata Hookeri*), of similar habit and appearance, occurs in Arizona and southern California. It grows around the borders of alkaline springs.

For holding embankments where a firm turf is required, *couch* or *witch grass* does excellently well in the Northern and Middle States. This well-known grass is widely distributed throughout the north temperate regions of the Old and New Worlds. It presents a number of forms, some of which have been regarded as distinct species. All are good hay grasses, but are objectionable in fallow land because of their widely spreading and very persistent jointed rootstocks. In the Northwest—Nebraska, Montana, etc.—there is a variety called "*blue stem*," which is very highly prized and much used for hay. In rich soil the stems grow to the height of 3 or 4 feet, and the heads have a striking resemblance to those of wheat. Hence the common names "wheat grass" or "creeping wheat," which have been applied to it by some. Couch grass makes a very tough sod, and is particularly valuable for binding railroad embankments, banks of canals, ditches, or other slopes which it is desired to hold in place. A well-marked variety of the species grows in sands along the sea coast, and is useful there as a sand binder.

Hungarian brome grass is a good turf former, and may be employed in much the same way as couch grass. The creeping rhizomes of the brome grass are not so strong as those of the couch grass, and as a soil binder it is less to be depended upon.

In the Southern States, where the couch grass does not succeed well, *Johnson grass* or the finer *Bermuda* (fig. 109) may be substituted for it. Johnson grass produces a great mass of extensively creeping, strong rhizomes, and when once the ground is filled with them it is almost

impossible to eradicate them. Bermuda grows more upon the surface, and upon a light or sandy soil succeeds better than Johnson grass. In binding together and holding levees of sand and loose soil against floods, in preventing lands from washing, or in filling gullies, Bermuda is of the greatest value, and at the same time is one of the very best pasture grasses for the South. If there is considerable moisture in the land, and the soil is somewhat clayey, *knot grass* may be substituted for Bermuda. In the Southern States knot grass is especially well adapted to cover silt or bare slopes on the banks of ponds or rivers, or for covering the soil of "sink holes." Moderate submersion does not injure it.

The species of *cord grass* (*Spartina*) have very stout, creeping rhizomes, and are of considerable value as holders and defenders of the soil. *Spartina juncea* and *Spartina glabra* are found on the Atlantic coast, while the stouter *fresh-water cord grass* (fig. 110) grows with these and also along the margins of fresh-water lakes and rivers.

The two first named form the basis of the salt marsh meadows which are so much valued along our north Atlantic Coast. *Spartina glabra*, with its varieties, is an excellent colonizer and land former in the situations where it flourishes, largely aiding in fixing and rendering solid the mud flats that accumulate about the mouths of rivers and low coasts, and for thatching this grass is more durable and otherwise superior to wheat straw. The largest of our Spartinas, *Spartina polystachya*, with stems 5 to 9 feet high and often an inch in diameter at the base, is common on tide-water marshes along the coast of New Jersey and Long Island. *Fresh-water cord grass* (*Spartina cynosuroides*) grows abundantly along the Missouri and other rivers of the interior, and especially along sloughs in the prairie regions, where it is best known as slough grass. It makes a fair but rather coarse hay when cut early, and it has been successfully employed in the manufacture of paper.

A striking species of *rye grass*,[1] called giant, or western rye grass, with strong rootstocks and stout culms, 3 to 12 feet high, grows in the Northwest and on the Pacific Slope. It is a grass which does good service in retaining the soil of the banks of streams and rivers.

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[1]An alphabetical list of the grasses mentioned in the foregoing paper, with the Latin equivalents of the English names, may be found in the Appendix.

SKETCH OF THE RELATIONSHIP BETWEEN AMERICAN AND EASTERN ASIAN FRUITS.

By L. H. BAILEY, Jr.,
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The fact must have struck every thoughtful horticulturist that Japan is now the most prolific source of profitable new types of fruits and hardy ornamental plants. The recent extension of communication with that country explains the introduction of these plants, but it does not account for the almost uniform success which attends their cultivation in this country. There must be some striking similarity between the climates and other conditions of Japan and America to enable plants from the very antipodes to thrive at once upon their introduction here. It is well known among naturalists that this similarity in climate exists, and that, therefore, there is general accord in the fauna and flora of Japan and eastern America. The origin of this resemblance was most strikingly explained by the late Asa Gray, professor of botany in Harvard University, so long ago as 1859. But this relationship of Japan and America, with the practical deductions which follow an understanding of it, has never been presented in its horticultural aspects.

Before proceeding to a discussion of Gray's argumentative paper, it should be explained that half a century ago there was no satisfactory explanation of the means by which plants and animals have become widely disseminated over the earth. This was particularly true respecting the curious phenomena of disconnected distributions, or the fact that some species occur in widely separated and isolated places. Certain plants occur only in eastern America and in Japan, and there may be no other representatives of the genus extant; that is, the genus is monotypic and has a peculiarly disjointed distribution. There are also certain bitypic genera, of which one species occurs only in eastern America and the other in Japan. There are equally strange distributions of plants and animals in other parts of the world. At the time Gray wrote, there were a few general hypotheses in vogue to account for these detached distributions. One was Agassiz's theory, which has been called the autochthonal hypothesis, from the fact that it supposes that each species was born or brought forth upon the area which it occupies (*autochthon*, one born of the land itself). It "maintains, substantially," says Gray, "that each species originated where it now occurs, probably in as great a number of individuals occupying as large an area, and generally the same area, or the same discontinuous area, as at the present time."

Much the same view was held by Schouw, of Copenhagen, who advanced the hypothesis of the double or multiple origin of species; but he supposed that the species had the power of greatly distributing itself when it was once created in a given region. It was even then (Schouw wrote in 1837) maintained by various naturalists that species had sprung from one progenitor; but Schouw declared that "when we look at the facts presented by existing geographical distribution, this hypothesis becomes highly improbable, in certain cases altogether inadmissible." All the known agents of the distribution of animals and plants could not account for the fact "that many species of plants are common, on the one hand, to the Alps and the Pyrenees, on the other to the Scandinavian and Scotch mountains, without these species being found in the plains or on the lower mountains lying between; that the flora of Iceland is almost the same as that of the Scandinavian mountains; that Europe and North America have many plants in common, particularly in the northern regions, which have not been transported by man; and still further difficulties, bordering on impossibility, arise for such an explanation when we know that species occur in the Straits of Magellan and in the Falkland Isles which belong to the flora of the Arctic Pole." In order to account for these anomalous distributions, he supposed that the same species may originate several times, although it would appear that this multiple origination is waning, from the instances which he cites of the less wide and not detached distribution of the mammals and the higher plants, which are, presumably, of comparatively late creation. "Just as we have seen that the leafless and flowerless plants are oftener rediscovered in distant countries than those bearing flowers, we may assume that the more perfect animals are less prone to, perhaps never do, make their appearance in several places independently." Schouw supposed that creation is completed. "I hold it in the highest degree probable," he writes, "if not strictly proved, that no new species originate at present."

The straits to which naturalists were driven to explain the distribution of animals and plants when one progenitor is alone assumed may be illustrated by the supposition which Schouw ascribes to an English author, that there must have been a continental area between Spain and Ireland, inasmuch as certain Spanish plants reappear in the British Isles. Even Alphonse de Candolle, while holding in general to the hypothesis of a single origin, felt obliged to admit that in the case of our modest verbena-like *Phryma Leptostachya*, which grows in eastern North America and again in the Himalayan region, there must have been two independent originations.

Naturalists were ready to believe that species had one origin, if only the fact of disconnected distributions could be explained. At this juncture Asa Gray came forward with his brilliant exposition of the relationships of the eastern American and Japanese floras. The plants collected in Japan in 1853 by Williams and Morrow, in connection with

Commodore Perry's visit to that country, and also those procured there by Charles Wright, in connection with Commodore Rodgers's expedition of 1855, went to Gray for study. He was at once struck by the similarity of many of the plants to those of our Alleghany region, a resemblance which he had before noticed. He found that many of the characteristic genera of eastern America and a number of the monotypic and bitypic genera occur also in the Japanese region. He observed the remarkable fact that the flora of eastern North America is much more like the Japanese flora than that of western America, or even of Europe, and also that our Alleghany flora is more like the Japanese than it is like the European.

RESULTS OF CHANGE IN CLIMATE.

It is well known that the climate of the Pliocene epoch, preceding the Glacial time, was much milder than now. Over the Dakotas, camels, horses, a mastodon, a rhinoceros, and an elephant roamed, and the temperate floras extended much farther north than they do at the present time. The same conditions prevailed in northern Asia, and the floras of the two continents were coterminous and intermingled. Then came on the Glacial epoch, "an extraordinary refrigeration of the northern hemisphere, in the course of ages carrying glacial ice and arctic climate down nearly to the latitude of the Ohio. The change was evidently so gradual that it did not destroy the temperate flora. * * * These [the plants] and their fellows, or such as survive, must have been pushed on to lower latitudes as the cold advanced, just as they now would be if the temperature were to be again lowered; and between them and the ice there was a band of subarctic and arctic vegetation, portions of which, retreating up the mountains as the climate ameliorated and the ice receded, still scantily survive upon our highest Alleghanies, and more abundantly upon the colder summits of the mountains of New York and New England, demonstrating the existence of the present arctic-alpine vegetation during the Glacial era, and that the change of climate at its close was so gradual that it was not destructive to vegetable species." So the plants were driven to the southward, both down the Asian and American continents. Gradually the ice melted away, the climate became milder, and plants began to return northward. After the Glacial epoch had passed away the arctic regions became warm. The great fluvial period came in, when arctic lands were lower than at present, when the sea stood 500 feet above its present level, and when the northern rivers were vastly larger than now. This great expanse of water and low elevation of land caused the warmer climate of the high north. Elephants and rhinoceroses roamed northward to the very shores of the Arctic Ocean, and lions, elks, horses, buffaloes, and mastodons inhabited the high latitudes. In the ice of Siberia the elephants are still found, even with their hair intact, preserved in Nature's refrigerator for ages. There is evidence that north-

western America and northeastern Asia were more closely connected by land than now. The Siberian elephant roamed from one continent to the other. "I can not imagine a state of circumstances," writes Gray, "under which the Siberian elephant could migrate and temperate plants could not." So the floras of America and Asia again became coterminous.

Now came another change. The Terrace epoch came slowly on. The arctic lands were elevated, the waters receded, and the temperature fell. The earth approached its present condition. The plants were again driven southward down Asia and America. The western coast of America, by reason of ocean currents, was warmer than the eastern region or than the Japanese region, and the temperate floras went down or persisted in similar climates, giving our Alleghany regions and eastern Asian and Himalayan countries similar floras. Subsequently only minor distributions have taken place. The eastern Asian flora has shown some tendency to extend westward, and some species have reached Europe. Thus we have an explanation of the remarkable fact, long ago noticed by Bentham, that American species have reached Europe through Asia.

"Under the light which these geological considerations throw upon the question, I can not resist the conclusion," writes Gray, "that the extant vegetable kingdom has a long and eventful history, and that the explanation of apparent anomalies in the geographical distribution of species may be found in the various and prolonged climatic or other physical vicissitudes to which they have been subject in earlier times."

A certain flora "established itself in Greenland," says Sir J. W. Dawson, "and probably all around the Arctic Circle, in the warm period of the earliest Eocene, and, as the climate of the northern hemisphere became gradually reduced from that time till the end of the Pliocene, it marched on over both continents to the southward, chased behind by the modern arctic flora, and eventually by the frost and snow of the Glacial age." Says Dawson, again:

If, however, our modern flora is thus one that has returned from the south, this would account for its poverty in species as compared with those of the early Tertiary. Groups of plants descending from the north have been rich and varied. Returning from the south, they are like the shattered remains of a beaten army. * * * It is, indeed, not impossible that in the plans of the Creator the continuous summer sun of the arctic regions may have been made the means for the introduction, or at least for the rapid growth and multiplication, of new and more varied types of plants. * * * What we have learned respecting this wonderful history has served strangely to change some of our preconceived ideas. We must now be prepared to admit that an Eden can be planted even in Spitzbergen; that there are possibilities in this old earth of ours which its present condition does not reveal to us; that the present state of the world is by no means the best possible in relation to climate and vegetation; that there have been and might be again conditions which could convert the ice-clad arctic regions into blooming paradises, and which at the same time would moderate the fervent heat of the tropics. We are accustomed to say that nothing is impossible with God; but how little have we known of the gigantic possibilities which lie hidden under some of the most common of His natural laws!

All these considerations go to establish three general laws: (1) That distribution of plants and animals is determined largely by climatic and other physical causes. (2) That species have a local or single origin. (3) That the origin of our present temperate flora is in the north. These generalizations were written before Darwin's theories appeared and before Heer had published the fossil histories of the arctic regions, and they at once establish Gray's place among philosophical naturalists.

We have now observed that the very facts which led Schouw, De Candolle, and others to accept an hypothesis of the multiple origin of species are the ones which chiefly explain and prove the conclusions of Gray. In the vicissitudes of geologic time plants retreated up the mountains or persisted along the cold shores of the northern lakes, giving rise to the curious fact of arctic and subarctic plants upon Lake Superior, Mount Marcy, Mount Washington, and Mount Katahdin. But, what is more to our present purpose, we can now understand the similarities of the eastern American and Asian floras, because like plants have persisted in similar climates when they were pushed down from the north upon all sides of the globe. The curiously dismembered diffusion of the *Phryma Leptostachya* is intelligible; and we can explain Schouw's perplexity concerning the less extended and undetached distribution of the mammals and higher plants, for these may, in many cases, have developed or originated since the epoch of these great dispersions.

The climates of eastern America and eastern Asia are still similar, as shown by the similar floras of the present time. The facies of the Japanese, northern Chinese, and Himalayan floras are strikingly those of our own Alleghany flora. The magnolias are peculiar to these two great regions. The tulip tree, confined to our Eastern States, has recently been discovered in China. The story of shortia and schizocodon—independent names for the same type of plant discovered in the two continents—is familiar to botanists. Lately, horticulturists have seen a striking instance of this relationship in the remarkably rapid diffusion in this country of the Japanese plums, fruits which are more closely allied to our native species than the common or European plums are, and which are also unquestionably adapted to a much wider range of conditions than the European plums. We all know that the horticultural flora most resembling that of Europe is upon our Pacific Slope; there the European wine grape, the olive, the citrous fruits, the walnut, the fig, and the prune and raisin industries are already well developed. In like manner we may expect that in the course of time the horticultural industries of eastern America and eastern Asia will acquire the similarity of facies which the floras of these regions now enjoy. One may therefore look with favor upon the introduction of Japanese plants, for it is certain, both from the known resemblances of its flora to our own and from the early introduction of its plants into

western Asia and Europe, that the most promising field for horticultural exploration and for the study of the ancestry of our fruits is now in the interior of China.

FOREIGN CONTRIBUTIONS TO OUR POMOLOGY.

It is yet too soon to fully measure the value of the contributions of eastern Asia to our pomology, although the importance of the hardy ornamentals derived in great numbers from that region is everywhere conceded. Yet this antipodean region has already given us quite as important species of fruits as Europe and western Asia, despite the fact that these latter regions were the source of our colonization and civilization. The following list includes all the fruits of the United States which have come from the Europo-Asian region and from the Chino-Japanese region:

Europo-Asian.	*Eastern Asian.*
Plum.	Japan plum.
Almond.	Prunus Simonii.
Apple.	Japanese pear.
Pear.	Peach.
Medlar.	Common apricot.
Sour cherry.	Chinese apricot.
Sweet cherry.	Wineberry.
Quince.	Kaki, or Japanese persimmon.
Raspberry.[1]	Orange.
Strawberry.[1]	Mandarin.
Red currant.	Lemon (including lime and citron).
Black currant.	Kumquat.
English gooseberry.	Loquat.
Wine and raisin grape.	Hovenia.
Olive.	Chinese jujube.
Pomegranate.	Litchi.
Date.	Elæagnus.
Fig.	Myrica.
Filbert.	Japanese walnut.
European chestnut.	Japanese chestnut.
English walnut.	Ginkgo.
Pistachio.	Twenty-one species.
Twenty-two species.	

The eastern Asian species of fruits now grown in this country are already nearly equal in number to those from Europe and western Asia—the latter country "the cradle of the human race"—and they comprise some of the most important fruits known to man, the orange, lemon, peach, apricot, and kaki. There is certainly abundant reason for looking toward oriental Asia for further acquisitions, either in other species or in novel varieties.

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[1] The raspberry and strawberry mostly supplanted by the American species.

FACTS CONCERNING RAMIE.

By Chas. Richards Dodge,
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HISTORY AND DESCRIPTION.

Who has not heard of the "grass cloth" of China, that delicate and most beautiful tissue which since time immemorial has been manufactured in oriental countries? Produced by rude hand manipulation from a fiber of gossamer fineness, extracted by equally laborious methods from coarse, woody stalks, there is, to the popular mind, something of the marvelous in its fabrication. The fiber employed is the ramie of commerce, known in the raw state as China grass, though it is not in any sense a grass further than that a handful of the greenish yellow filaments has a grass-like appearance. The plant from which this delicate and astonishingly strong fiber is produced—one of the strongest and most durable in the fiber economy—may be described as a cluster of tuberous roots surrounded by a mass of fleshy rootlets, supporting a growth of 10 to 80 stalks which shoot upward to a height of 4 to 8 feet. At maturity these stalks vary in dimension from the size of a lead pencil to the thickness of a man's little finger.

The stalks are clothed with large ovate-acuminate leaves of a warm, green color on the upper surface, and whitish or silvery beneath (in the variety known as *Bœhmeria nivea*), the fiber being formed in the bark surrounding the woody portion, this having a pithy center protected on the outside by a thick epidermis. The plant grows rapidly, producing two to four and even five annual crops without replanting, dependent upon the country and climate where cultivated, and one planting suffices for several years.

Almost a century has passed since the attention of the government of India was first called to the value of this fiber in the textile economy by Dr. Roxburgh. About 1840 a second attempt was made to utilize the plant, but it was not until 1869, when a prize of £5,000 was offered by the British Government for a satisfactory process or machine with which to supersede the laborious hand methods of cleaning the fiber, that serious effort was inaugurated.

Probably no fiber in the vegetable economy has attracted such widespread interest as ramie, for nearly every government on the face of the globe, in countries where the plant will grow, has encouraged the establishment of the industry in one form or another, or capitalists in these

countries have liberally aided invention and private experiment in the hope of securing the golden reward it has offered. Through these unremitting efforts, and the lavish use of private capital, there is now a flattering prospect that the industry will ere long be fairly established, and ramie fabrics will be found in the markets of the world side by side with those from silk, from cotton, and from flax. European concerns even now are running thousands of spindles, turning out hundreds of tons of yarns annually, and are enlarging their works.

THE INDUSTRY IN AMERICA.

It is nearly forty years since the plant was introduced into the United States, and a quarter of a century marks the period of our struggle with the decorticator problem. Experiments in culture during this period have demonstrated that the plant will grow thriftily in the Gulf States from Florida to Texas, and in certain localities in California, such as the valleys of the central and southern portions of the State. It has been shown that after the first year two to four crops annually may be expected from one planting, dependent upon locality, and that the ground will not need to be again disturbed for four or five years.

But it has also been demonstrated that we have yet a great deal to learn regarding the details of cultivation, as the profitableness of the crop must depend wholly upon the yield per acre of spinnable fiber. The cultural problem of the immediate future, then, will be to learn how to produce on a given area the greatest quantity of fiber of spinnable quality at a cost that will allow of competition with other countries. This means careful experiments not only in culture but also with the stripping, cleaning, and after-manipulation of the fiber derived from these experiments, to ascertain the precise yield, quality, cost, and commercial value. In other words, it is not enough to grow a crop of stalks of the requisite height and size—we must know that these stalks contain the proper quality of fiber, in sufficient quantity to make the culture profitable; and we must know all the conditions essential to bringing about such results.

Between the Chinese imported and the home-grown fiber there will always be this disadvantage and difference: The machine-prepared fiber can never be so clean and free from gum, and therefore will bring a lower price, the range dependent upon the percentage of pure fiber it contains and upon the thoroughness of decortication. This difference is clearly shown on Plate V.

COMPARISON OF RAMIE AND FLAX.

Comparison between ramie and flax will illustrate some of the difficulties with which the ramie industry has had to contend, and show why ramie can not be grown, cleaned, prepared, spun, and woven as cheaply as flax and other textiles the production of which are recognized industries.

RAMIE—DRIED STALKS, RAW FIBER, DEGUMMED FIBER, AND MANUFACTURES.

Ramie is a coarse, pithy stalk, with an abundance of leaves, often growing as high as a man's head, the fiber of which is extracted with difficulty by costly machinery, and which, after drying, must be further subjected to chemical treatment before it can be sold to the manufacturer in the form of degummed ramie. And according to French experts this degummed ramie represents hardly more than 2 per cent of a given weight of the green stalks with leaves that were harvested from the field. In harvesting a ton of flax the semidried straw is pulled from the ground, and it is only necessary for it to remain in the shocks for a few days when it becomes thoroughly dry like the straw of wheat or barley, having lost only its moisture. In harvesting a ton of green ramie we are handling 80 per cent of water and a mass of leaves and succulent tops equal to a weight of eight or nine hundred pounds to the ton. If the dry system of decortication is to be employed these stalks must be shocked in the field and handled several times, so that all the leaves may fall to the ground and the air reach every part of the shock, and even then the stalks will not sun-dry to brittleness in the Gulf States.

METHODS OF DECORTICATION.

If the green system of decortication is to be followed, this great bulk of succulent material (8 to 12 tons per acre) must be harvested and hauled to the machines, and if the machines will not strip the leaves automatically—for the stalks must be worked at once, while fresh—the stripping must be accomplished by hand. The requisite number of machines will be regulated by the area under cultivation, for a single decorticator that would even clean the product of an acre in a day would only be able to finish, say, 50 acres in eight weeks of working days. It will readily be seen, therefore, that if the fiber has reached proper maturity when the cutting begins at the end of eight weeks it must suffer a change that will give different grades of fiber in the same crop. Hence, only the farmer who grows a very few acres may expect to harvest his fiber with one machine if he desires to secure an even standard of quality, unless he resort to the dry system, with which the fiber may be extracted at any time, provided the stalks are thoroughly dry.

In comparing the different methods of treatment of these two fibers, flax and ramie, it will be readily seen that one is simple, chiefly mechanical, the retting being accomplished by nature at small outlay for labor; the other quite complex, requiring the handling of 8 to 10 tons, or even more, of green matter per acre, which must either be dried or passed through a machine while in fresh condition, and the ribbons finally subjected to chemical processes requiring more or less of technical knowledge and the employment of special apparatus. Flax, which is treated so simply, yields from 15 to 25 per cent of fiber, while ramie yields hardly 2 per cent of the weight of green stalks and leaves

harvested. The cost of retting, breaking, and scutching flax, to secure its fiber, is a known quantity; that of ramie, at present, is unknown.

To the advantage of ramie over flax, in our comparison, let it be said that, under proper cultivation, an acre of the former should produce, in its two crops, 16 to 25 tons annually, while 1 or 2 tons of straw is all that can be expected in an annual crop of flax, save 12 or 15 bushels of seed that should be reckoned into the account. Then flax must be grown from the seed annually, while one planting of ramie roots will give crops for several years.

The question is frequently asked, Does the Department of Agriculture encourage cultivation at the present time? The Department certainly advocates *experimental* cultivation, in order that farmers may become familiar with the growth of the plant, and also to insure a supply of roots for more extensive planting when all the other problems have been solved. And it is true that at the outset, when the time comes that cultivation may be profitably engaged in, there will be a large demand for roots, which for a few years will assure a profitable revenue to those who have a supply to draw upon. But in this experimental culture not over two or three acres should be put under cultivation by one farmer, and he should go to work intelligently, keeping both eyes open, and without expectation of immediate money return. By this statement it will be understood that the United States Department of Agriculture can not encourage cultivation as a money crop, in connection with the regular staples, as long as the decorticator problem remains unsettled and the farmer can not be assured of a ready means of converting the crop into salable fiber that will compete with the hand-prepared China grass of commerce. The foreign product can now be supplied to manufacturers at from 6 to 8 cents per pound, and is almost wholly relied upon as the supply of raw material used in the European ramie-manufacturing establishments, and the same must be said of our own country until the home-grown fiber can be more economically produced and extracted than at present.

CLIMATE, SOIL, AND CULTURE.

In general terms it may be said that the ramie plant requires a hot, moist climate, with no extremes of temperature, and a naturally rich, damp, but never a wet soil, the necessary moisture to be supplied by frequent rains or by irrigation; in other words, a climate and soil in which the growth will be rapid and continuous after it has once begun. In the United States the best localities, so far as experiment has determined, are portions of Florida, Mississippi, Louisiana, and Texas, on the Gulf, and central California, on the Pacific coast. The other Gulf States, doubtless, will prove equally favorable to this culture, when more extensive experiments have been undertaken than are now recorded. Regarding the northern limit of commercial culture, no positive statement can now be made. The plant thrives in South Caro-

lina, and it is fair to suppose that two annual crops are possible, though the quality and yield of the fiber can only be ascertained to a certainty by careful tests of the product of both crops.

Mr. William R. Smith, the Superintendent of the United States Botanic Garden, Washington, D. C., considers the District of Columbia the northern limit of its growth, botanically speaking. But commercial cultivation in this locality or in Maryland or Virginia is out of the question, for only in particularly favorable years will the plant make a good growth, and even then but a single crop will be possible. In 1894 the entire season's growth of the little plat at the Botanic Garden was barely 3 feet high, and the clusters of flower racemes had not begun to mature their seed on the 1st of November; and cultivation northward from the District of Columbia, for instance in the State of New Jersey, as recently suggested, must be set down as a mere vagary.

The question of soil is an important one. In the present day the soil usually chosen in China is a red clay, "with sand mixed in," and the plantation is established with roots dug from old plats in the fall. In India the plant appears to thrive in almost any soil, though preference is given to rich, light sandy loams, thoroughly worked. In the Kangra district "rich loams" are chosen. The French experimenters, whose experience relates to France, Spain, and Algeria, prefer a deep soil—"silico-calcareous, or sandy alluvial with a permeable subsoil." But marshy lands or retentive clay soils are always avoided.

In our own country, in the Gulf States, ramie has been grown experimentally in a great variety of soils, ranging from the light sandy uplands to the rich black lands of the Louisiana bottoms. But light sandy alluvial soils have always given the best results. In California deep alluvial, sandy, or loamy lands which, when well prepared, will hold their moisture through the growing season, or that can be irrigated, are most commonly selected.

In preparing the land for a plantation, thorough tilth—that is, deep plowing and cross harrowing—are essential. The ground is frequently broken to a depth of 15 inches or more, but never less than 12 inches, to secure good results; and lumpy land is rolled.

In all countries where ramie has been grown commercially or experimentally the necessity for heavily enriching the soil by the application of the farm manures or chemical fertilizers is emphasized. It was shown many years ago by Forbes Watson that the alkalies, especially potash, amount to almost one-half and phosphoric acid one-tenth of the weight of the ash constituents from a plant of ramie, or about 80 pounds of the former to 40 pounds of the latter in a ton of dried stalks. As a crop of wheat is said to take from the soil but 30 pounds of alkalies and 28 pounds of phosphoric acid, the importance of properly enriching the soil will be readily understood. The amount of mineral constituents found in the fiber is very small, and as the fiber is the only valuable portion of the crop, the leaves and woody waste, or the refuse of

decortication, can always be returned to the soil. The French writers lay great stress on the use of the leaves for fertilizing material, as they are rich in potash. The leaves alone that are produced upon one acre may amount to 4 or 5 tons weight for each cutting.

Professor Hilgard's experiments at Berkeley, Cal., in this direction are very interesting. He makes the total of mineral ingredients withdrawn from the soil in a single year, four cuttings, 2,143 pounds. Among these are lime, 658 pounds; potash, 252 pounds; phosphoric acid, 156 pounds, and the figures for nitrogen are 370 pounds. The stalks contain about three-fifths of the potash, and the leaves one-quarter of the total. Nearly 87 per cent of the lime, 50 per cent of the phosphoric acid, and 55 per cent of the nitrogen is found in the leaves.

We learn, then, that lime, potash, phosphoric acid, and nitrogen are the constituents of a proper ramie fertilizer, and these elements of fertility may be supplied in several ways. If the refuse of a ramie crop is burned and returned to the land with the leaves a large saving in the purchase of fertilizers will be effected. According to Professor Hilgard, should the leaves and not the stalks be returned to the soil the amount of potash permanently removed from the soil would be increased by 156 pounds—lime, 72; phosphoric acid, 78; and nitrogen, 106.

A good ramie fertilizer recommended by Mr. S. B. Allison, a Louisiana ramie grower, is 300 pounds each of cotton-seed meal and kainit. Professor Stubbs uses two parts cotton-seed meal and one part acid phosphate at the rate of 400 to 480 pounds per acre. In French practice well-decomposed stable manures and well-ground chemical fertilizers, guano, and oil-cake have been used successfully.

The land having been put into proper condition as to tilth and fertility, the preparations for planting follow, but before considering this point in the agricultural practice it will be well to know what the farmer is to plant. Three methods of propagation of the ramie may be followed: (1) By the use of seed; (2) the employment of subdivided roots, and (3) the practice of layering. Ramie plantations are most commonly established by the planting of roots, the stand being supplemented by layering the shoots that spring from these roots, thus rapidly multiplying the individual stools, or hills, from which the clusters of stalks will spring. Thus, by planting roots instead of seed, time is saved and stronger plants are secured at the outset.

If, however, roots can not be obtained in sufficient quantity, the necessary plants must be produced from the seed—an operation requiring the utmost care, as the seed is very small. Outdoor propagation can hardly, therefore, be relied upon, and the young plants must be grown in the hotbed or cold frame. The principal care is to avoid covering the seed with more than a light sifting of fine earth, also to keep the bed moist and to protect the young plants from the sun. When they are 2 or 3 inches high sunlight may be admitted, and in five or six weeks they may be planted out in the field. The Chinese mix 4½ pints of fine

moist earth with 1 pint of seed, and by the use of earth and seed thus mixed no covering is necessary. A pint of seed will suffice for six or seven beds, each containing 4 square feet of surface.

For root planting the supply is obtained from the root masses of old plants, these being subdivided into lengths of 4 or 5 inches, containing several eyes. Twelve hundred bushels of roots have been taken from a single acre in an old plantation, that were sold for $1 a bushel. Reference may be made to the illustration of roots which accompany these pages. The top or crown roots (fig. 111), which resemble small, slender tubers, are never employed, and should be thrown out when the old roots are subdivided. The old roots are shown in figure 112.

FIG. 111.—Plant showing crown roots.

FIG. 112.—Plant showing roots to be subdivided.

In preparing for planting, the first step is to cross-plow, harrow, and roll the ground that has already been fall-plowed and harrowed. This may be done about the 1st of February. Mr. Allison's practice is to allow the land to lie for one month after this is accomplished before laying up the surface in flat beds, which should be 4½ feet from centers, the centers having an elevation of 6 inches. The rows are barred off with a scooter plow to the depth of 4 inches; the roots are then placed in the rows and covered with two furrows. A week later, when the roots have begun to sprout, a harrow with a board at the back of it is run over the ground in order that the plants may push up in mellow soil.

There is the greatest difference of opinion in regard to the proper distances apart that the plants should be set, but a safe mean will be to establish the rows 4 to 4½ feet apart with the plants 1 foot in the row; in California somewhat closer setting is practiced. The close

system of planting recommended by the French requires 14,000 to 16,000 plants to the acre, while the 4 feet by 1-foot system requires only about half as many plants to the acre.

Layering is practiced when the stalks from the first growth are about 3 feet high. The earth is mellowed and made damp, the stalks bent and held in place by crotchets, and covered with about 4 inches of soil. In four weeks they will have become independent plants, which may be left in their places to form new stools or may be transplanted in other plats. Another method of propagation has been recommended in California, which, in brief, is to set out obliquely sections of stalks some 6 inches in length, nearly covering them with earth. It is claimed that if the work is accomplished before the period of hot weather, no

FIG. 113.—Ramie stalks ready for cutting.

FIG. 114.—Stalks of ramie showing new growth of leaves.

special care, as watering and shading, will be necessary, though all weed growth should be kept down. The planting in Egypt, Algeria, and Spain is done from the end of October until April; in France, from March to the end of May.

The only after-cultivation necessary is to plow or hoe between the rows, as may be necessary, to keep the soil free from weeds or in good condition. This work is usually performed in the spring or early summer months. As to the operations of the second year, the detailed account of Mr. Allison's experience will give a hint of the practice that should be followed. Early in April, when the danger of frosts had passed, all young growth was cut off but not saved. Fertilizers were

applied, and the soil between the rows plowed and hoed. About the first of July the first crop was cut, followed by another plowing and hoeing. The stalks were then allowed to grow until about November 1, the time for the second cutting. I think, however, it would be better not to delay the last cut so late, in order to avoid a "second growth" which takes the form of clusters of leaves, eventually producing branches, which appear at the point of juncture of the leaf and stalk after the old leaves have fallen. The accompanying figures illustrate this: Figure 113, the stalks and growth of alternate leaves; figure 114, with the beginning of a new growth of leaves at the point of contact of the old leaf with the stalk; figure 115 shows clusters of flower racemes and formation of seed.

"What is the expense of establishing a ramie plantation?" asks the farmer. At the present time it is difficult to answer the question, because the cost of roots, the chief expense, depends largely upon demand and supply. It will be a simple matter to figure out the cost of plowing, harrowing, and planting, and we may even assume a price for roots, but the figures must apply only to the present time, when the demand for roots is limited.


FIG. 115.—Seed-bearing racemes.

In this country ramie has never been grown over large areas, and the records of experiments that appear in the meager literature of the subject are very vague and incomplete. The figures given are made up from a careful analysis of returns received in reply to a special circular on this subject, and while the results will not be found far out of the way, these figures must not be regarded as absolute. By the Louisiana Experiment Station the first year's expense is set down at $20, the cost of fertilizers and of roots not given. The Mississippi Experiment Station figures, including cost of fertilizers but not of roots, are $19.50. Mr. Natho, a Texas grower, makes the statement that the expense of preparing the land, planting, and after-cultivation for the first year will amount to $21.50. Mr. S. B. Allison's figures, including fertilizers to the value of $12 and the labor of layering a part of the first growth, are $24. Mr. Allison's land was very poor, and required a large amount of fertilizer.

The figures of the United States Department of Agriculture, based not only upon the returns from the circular but upon all available information that could be secured from other sources, without counting the cost of roots, amount to $25.88 per acre. This allows for fertilizers $9 and for the labor of planting $8. By these returns the expense of the second year's cultivation, with fertilizers, is shown to be only $13.25.

HARVESTING THE CROP.

In general terms, a crop of ramie is ready for cutting when the leaves can be readily detached by passing the hand down the stems, and when the bases of the stalks have begun to turn brown. The sprouting of the buds at the base of the leaf stem is another indication. No rule as to dates can be laid down, as temperature and climatic conditions vary so greatly in different sections and in the same section in different years. In France the first crop is cut from June to July and the second from September to October.

It is a question whether we can economically harvest in this country by hand cutting, especially if the stalks are stripped of their leaves in the field. Then, too, the system of decortication to be employed, whether the green or the dry, will need to be considered. Mr. Kauffaman states that the harvesting can be readily done by reaping machines or self-binders, which will reduce the expense to the minimum. If this mode is adopted without stripping the leaves, the decortication must follow immediately, for the mass of stalks and leaves will soon heat and the stalks rapidly mold or mildew. Personal observation at the time of the ramie trials of 1892 at New Orleans leads to the conviction that heating may begin in twelve hours, and that the bundled stalks will show positive signs of mildew within twenty-four hours. With stripped stalks the heating will be less rapid, but even when denuded of their leaves and lying in heaps, the stalks will soon be affected to an extent that will seriously injure the fiber.

It is not believed that ramie in Louisiana can be sun-dried to a state of sufficient brittleness to give best results in working; and kiln-drying will not only cause additional expense, but may result in injury to the fiber by overhardening the resinous principle or gum holding the filaments together. The dry system seems best adapted to California, where the climatic conditions differ so greatly from those of the Gulf States.

The Chinese strip the fiber by hand, producing, it has been stated, less than 2 pounds per day per laborer. This practice admits of careful selection of the stalks, and no doubt the even quality of the China grass of commerce at the present time is due to such careful selection. It is a question, therefore, if cutting the crop with a harvester, as has been recommended, where the stalks will be of varying lengths, even including short and immature growth, will produce an even quality of fiber. Such careful selection of stalks in our own practice can hardly be recommended, owing to the extra expense it would involve, but there is no question as to the enhanced value of the fiber that would result.

It has been shown that a crop grown in a rainy season will produce a softer, less resistant fiber than one grown under normal conditions, and it follows that there may be similar variation in parts of the same stalks that have been grown in successive periods of inundation and drought.

These facts only emphasize the importance of harvesting mature stalks, and it should be the aim of the cultivator to bring about, as far as such control may be in his power, those conditions of growth that will insure even maturity.

YIELD OF RAMIE.

Estimates of yield, as a rule, are overstated. In the past newspaper literature of the subject the tendency has been to "boom" the industry by telling only the bright side of the story, or by advancing alluring "probabilities," the exaggerations, in rare instances, approaching the marvelous. But in spite of the enthusiastic utterances of the mere promoter, and the overzealous assurance of the misinformed news-chronicler, few farmers have gone into cultivation recklessly, though some capitalists have lost money in unwisely conducted experiments.

To get at the truth of the matter a careful study has been made of the figures of our own and other countries, the figures of actual experience being selected as the basis of estimate; and it has been possible to find a key by which the published figures of estimate from small areas may be tested.

According to Hardy's experiments in Algiers it is estimated that an acre of fully grown green stalks, with their leaves, will produce a weight of about 48,000 pounds, which will yield 4,900 pounds of dried stalks and 1,400 pounds of cleaned ribbons from one cutting. This, reduced to equivalents, gives a yield of 229 pounds of dried stalks to a long ton of green stalks with leaves, from which is obtained about 65 pounds of cleaned ribbons, yet to be degummed. This is equivalent to 630 pounds of ribbons from a ton of dried stalks. Professor Hilgard estimates two cuttings in California to yield 12,900 pounds of dry stalks, and that the minimum product of raw fiber from this weight of dry stalks would be about 15 per cent, or, say, 1,935 pounds. This is equivalent to 336 pounds of raw fiber to the long ton of dried stalks. Both the Algerian and Californian figures represent estimates based on the yield of small areas (hardly more than garden plats), and should not be taken as absolute. Indeed, Mr. Hardy's yield per acre of 96,000 pounds of green ramie per year (two cuttings) is not paralleled in any ramie literature that has come to my notice.

In De Mas's Italian experiments two cuttings the second year gave a product of 52,000 pounds of stalks with leaves per acre, or 27,600 pounds of stripped stalks giving 9,800 pounds of dry stalks, and yielding 944 pounds of dry fiber. This means 472 pounds of fiber from one cutting, or 40 pounds of raw fiber from 1 ton of green stalks. Percentage of dry to green stalks 10 per cent, and of dry fiber to dry stalks 17.9 per cent. These percentages are much nearer the mark, and may be more safely taken.

Regarding Dr. Hilgard's figures, it should be stated that the product is estimated from actual cuttings on two plats, about one seventy-first

of an acre. The high rate of yield at Berkeley is readily accounted for by the fact that in these small plats (18 by 34 feet) the crop was grown under the best possible conditions, and doubtless with garden culture. Similarly measured plats of second crop Louisiana ramie, cut at my request by Mr. Allison, when weighed showed a yield equivalent to 23,000 pounds and 25,000 pounds in round numbers per acre, the first lot being white ramie, the second lot green ramie, and Mr. Allison is of the opinion that with good culture this yield may be maintained. This is equivalent to 20 and 22 tons of green stalks and leaves per acre annually.

A careful study of the yield of all countries justifies as a fair estimate 8 to 10 tons of stalks with leaves per acre at a single cutting, or for two cuttings, which is the average for Louisiana, 20 tons; and it is possible, under the most favorable conditions, to secure a yield of even 25 tons per year after the plants are well established.

The careful experiments of Mr. Charles Rivière, director of the Botanic Garden of Algiers, have given us a ready basis of estimate of yield where ramie has been properly grown. These figures have been proved by the later experiments of Landtsheer. A French ton (1,000 kilos= 2,200 pounds) of stalks and leaves will yield 520 kilos (1,144 pounds) of stripped stalks; the 520 kilos of stripped stalks will give 104 kilos (228.8 pounds) of dry stalks, and these will yield 20.8 kilos (45.7 pounds) of decorticated product (a little less than 20 per cent), and this weight will give 11.2 kilos (24.6 pounds) of degummed filasse. This means that a long ton of green ramie stalks with leaves will yield 46½ pounds of decorticated fiber, which will give 25 pounds of degummed fiber, and calculations made on this basis will never be overstated or misleading. The figures of De Mas are 40 pounds of fiber per ton of well-grown stalks and leaves for first year's growth, and 44.2 for second year's growth. In our own country Mr. Allison's experiments have given very nearly the same results, having himself grown the stalks and extracted and degummed the fiber.

It is only through such practical experiments, covering the whole ground of production of the fiber, decortication, and degumming, under one direction, that we shall ever be able to solve the many problems that beset the industry.

Regarding the number of cuttings that may be depended upon in the United States there is but one point to consider, and that is the number of crops that will mature sufficiently to produce spinnable fiber of even quality in the different cuttings. Taking ten weeks as the average time required to mature the crop, three crops would require a growing season of thirty weeks. If the climatic conditions of the section where the crop is growing are such that the requisite degrees of heat and moisture can be kept up uniformly for a period of thirty weeks, then three crops can be readily grown. If, on the other hand, the first and third crops are of slow growth, while the second crop, which has

been produced in midsummer, is of rapid growth, a uniform grade of fiber in the three crops can not be produced, and two sure crops will, therefore, be better than one sure and two uncertain crops. In order to grow two sure crops the early spring growth will need to be mowed off, say, from the first to the middle of April.

It is believed, therefore, that two cuttings are possible in Texas and Louisiana, three in portions of Florida, and, as has already been stated by Professor Hilgard, from two to four in California.

EXTRACTING THE FIBER.

It is not important to record here the consecutive history of ramie-machine invention in America, particularly as it would necessitate describing almost a score of machines that, one after another, were brought to the attention of the public for a time, only to be practically abandoned when it was proved that they were unable to fulfill the claims of their inventors. Since 1867 the persevering effort to produce a satisfactory machine has naturally resulted in a gradual improvement in mechanical construction; new principles have been worked out and the causes of subsequent failures studied, with the result that substantial progress can be recorded, though full economic success can hardly be claimed.

Ramie machines may be divided into two classes: (1) Delignators, or simple bark strippers, and (2) decorticators, which not only remove the bark but make some pretense of removing the outer pellicle, or epidermis, and the layer of cellular matter covering the fiber layer proper. The bark strippers produce the fiber in the form of flat ribbons, only the wood of the stalk being eliminated; they are usually constructed with some form of knife, or knives, with which the stalks are split before being subjected to the action of the breakers and beaters. The decorticators usually first crush the stalk by means of metal rollers presenting the flattened mass to the action of the breaking or beating devices, and frequently there is a system of mechanisms for combing the fiber before it is finally delivered to the aprons. The product of the delignators is always the same—a flat ribbon of bark, whether the dry or green system of decortication has been employed. The product of the decorticators, on the other hand, is almost as variable as the machines which turn out the fiber. In some of the worst machines this product is little more than a mangled strip of bark, neither a delignated ribbon nor decorticated fiber, but something more fit for the trash heap. In the best of them, individual filaments, by the green system, somewhat resemble China grass, though darker and less clean, while by the dry system the fiber is already soft enough to spin into coarse cordage without further manipulation. Between these two extremes every quality of ribbon is represented.

Taking China grass, or commercial ramie, as the highest form of the fiber, since it is degummed with a loss in weight of only 15 to 30 per

cent, it will readily be seen that the value to the manufacturers of the machine-cleaned ribbons must be in exact ratio to the degree to which the cleaning and freeing from gum have been carried. The simple delignated ribbon, containing all the gums, cellular matter, and epidermis, must be the lowest form of raw fiber, as it will show the largest percentage of loss (extraneous matters) in the after-process of degumming; and the expense of degumming, according to French experiments, is shown to be in direct ratio to the bulk of foreign matters to be eliminated. This, however, will be referred to in its appropriate place further on. (See Plate V showing hand-cleaned and machine-cleaned fiber.)

But we have considered that these different products or grades of product differ only in the degree to which the elimination of the gum and waste matters has been carried, and that the proportion of gum, cellular matter, and epidermis is the only consideration. In point of fact the product of many machines which otherwise might be called good fiber has been so filled with fragments of the woody portion of the stalks, or so "chewed up" by harsh treatment, or, finally, so snarled and tangled in the delivery that it has had little value for any purpose. The product should be delivered straight, unsnarled, and untangled, free from chips, and without breaks, cuts, or bruises, whether in the form of stripped bark or semicleaned fiber, and its value will be determined by the percentage of pure fiber it contains.

We may fairly assume, then, that the nearer a machine approaches in its product the ramie of commerce, Chinese hand-cleaned fiber, the higher the price of its product and the more desirable the device producing it as an economic agricultural implement.

Having discussed quality of fiber produced let us turn our attention to that other great problem, the question of quantity or output. In my first report[1] is an account of the running of five French machines several years ago, and the record of one of the best of these machines in a field trial (in 1888) was commented upon. A single machine worked twenty-five days on the product of one hectare, or 2½ acres. With 20 acres at this rate it would have required two hundred days, and a farmer with one machine, decorticating three crops produced in a season, on 100 acres, would have to run the machine ten years of three hundred working days each to accomplish it. To state it differently, to decorticate at this rate the product of a single cutting on 100 acres, in one month of thirty days, would require 33 machines. Yet one can imagine the French attendant of this machine, who is showing it off to a novice, sending three stalks through the mechanisms in as many seconds, and with a complacent "Voila, Monsieur!" presenting the beautifully cleaned fiber to his delighted gaze. Such an exhibition before a capitalist who has not "read up" is sometimes worth the value of a hun-

[1] No. 1, Fiber Investigations Series, United States Department of Agriculture.

RAMIE IN DETAIL: 1, RAMIE STALKS; 2, MACHINE-CLEANED FIBER;
3, CHINESE HAND-CLEANED FIBER.

dred shares of stock (at par). But ramie machines have been vastly improved since 1888, and it is now possible to run through the product of an acre in a day, without, however, considering the question of quality. It would doubtless prove interesting to speak of the many machines that have appeared at the official ramie trials held in this and other countries in past years, but limited space forbids.

At the New Orleans machine trials of 1892 the machines ran on stalks that had been stripped of their leaves by hand, and no machine was able to run through the first 500 pounds of stalks weighed out, on account of stoppages, and finally the trial was abandoned. In 1894 the machines took the stalks with their leaves, as hauled from the field, and worked continuously. The quality of the product of decortication at the first trials was little better than simply delignated ribbon, some of it badly bruised and injured; at the second trial the decortication was excellent, though one machine seriously injured its product in the delivery. This shows decided progress, and one of the immediate results of the trials just held will be the further improvement of both machines exhibited, the work having already been undertaken. Reviewing the experience of even the last five years, we are able to record such substantial progress in machine construction that the outlook is hopeful, and experimenters are beginning to feel great encouragement.

AFTER-PROCESSES AND MANUFACTURE.

Those who are familiar with the varied processes of the extraction and first preparation of the fiber of flax and hemp know that there are four stages, or operations, between the work of the farmer and that of the manufacturer, as the retting—in water or upon the ground—breaking, scutching, and finally the hackling, which combs out the tow and leaves the fiber in shape for the manufacturer. With ramie the retting is omitted, and the stalks are broken and cleaned either green or dry with all the gums in their natural condition. This corresponds to the breaking and scutching in the treatment of flax, the two operations being combined in one when the work is done on a machine. Before the ramie fiber is hackled (combed), however, it must be subjected to a chemical operation analogous to retting, to which the French have given the name *degommage*—hence the English term degumming. The gums holding together the filaments of flax are soluble in water, and therefore the retting accomplishes the separation of these filaments without difficulty. The gums which hold together the structure of ramie bast are not soluble in water, but require peculiar chemical treatment, which can be more economically applied to the extracted fiber than to the fibrous substance as it exists in its natural state in the stalks as harvested. Owing to this fact the retting, or degumming, of ramie is usually done by the spinner, who, knowing the use to which the prepared fiber will be applied, degums the raw product to suit his own special needs. The farmer, then, has nothing to do with this operation

and need not interest himself in it further than to know whether his product when extracted and degummed is fit for spinning, or, in other words, is up to a standard of quality that will insure profit from the culture. This operation is not connected with the work of decortication.

Through the researches of the late M. Fremy, member of the French Institute, it has been shown that the gums and cements holding together the filaments of ramie are essentially composed of pectose, cutose, and vasculose, while the fiber itself is composed of fibrose, cellulose and its derivatives. The theory of degumming, therefore, is to dissolve and wash out the gums without attacking the cellulose. In order to eliminate the vasculose and cutose it is necessary to use alkaline oleates or caustic alkalies under pressure, and even bisulphites and hydrochlorites. The gums being dissolved, the epidermis is detached and can be mechanically separated from the layer of fiber by washing. The larger number of degumming processes in present use embody these general principles.

Lest it may be understood that it is only necessary to place *any* raw ramie fiber in the degumming bath to separate at once its different constituents, at a fixed cost, it should be recognized that upon the degree of cleanness of the fiber to be degummed depends the expense of the operation. It has been held by some inventors, or others controlling machines for decortication, that it makes little difference whether the ribbon to be operated upon is simply stripped bark or a well-decorticated product, as the resolving agency, followed by a volume of water, may be depended upon to render the separation complete and to wash out all extraneous matters, giving the pure fiber. The quantity that may be turned out in a given time, rather than quantity with quality, has been the main consideration. The waste matters in the bark of the ramie stalks must be wholly eliminated before the fiber is fit for the spinner, and if the machine does not accomplish any part of this work the degumming bath must do it all, but at a cost in direct ratio to the percentage of waste matters that remain in the ribbons after leaving the machine.

French experimenters have shown that it costs no more to degum the China grass that will fill a kier, or tank, of certain dimensions than the charge of simple stripped ribbons that will fill the same tank. Yet the weight of China grass that will fill this kier will be almost double that of the stripped bark; and while the kier of China grass will show a shrinkage (waste) of only 30 per cent, let us say, the shrinkage for the stripped bark may be 66 per cent. To state this differently, a half-ton charge (1,120 pounds, French) of China grass may give 775 pounds of degummed fiber, the expense of degumming (at $20 per charge, let us say) being about $2\frac{3}{5}$ cents per pound. Now, the same kier, when charged with simple stripped bark, will hold only 660 pounds, and give but 264 pounds of degummed filasse. But as the cost of degumming the contents of the tank will be the same in both instances, the last

operation has cost 7½ cents per pound for each pound of pure fiber turned out. These figures are from French experiments made several years ago, recorded in Mr. de Landtsheer's brochure The Truth About Ramie, and the cost of degumming has since been somewhat cheapened. At the present time the cost of the operation of degumming is about $50 per ton of finished fiber, and the commercial value of the fiber about 13½ cents per pound.

It should be stated regarding the degumming process in use in this and other countries, that they are either patented or secret processes, and as such the Department has made no special investigation into their comparative merits, and has no official knowledge of the formulas employed. But at the same time, many specimens of the finished fiber produced by these processes have been received, carefully examined, and preserved in the reference collection of the Office of Fiber Investigations, United States Department of Agriculture.

In recent years a number of more or less successful factories have been started for the production of ramie goods from the China grass of commerce, notably the German factory at Emmendigen, the Austrian mill at Bregenz which has recently been purchased by an English syndicate, the French association of Feray et Cie. at Essones, of A. Goulon at Rouen, and others, the companies operated so successfully by Mr. Favier, at Valobre, and latterly in England, where the recent success of French experimenters in economically degumming the fiber has led to the establishment of new companies for the production of ramie goods, one of these being the Boyle Fiber Syndicate of London.

At the present time there are two filatures, or spinning mills, in France, two in Germany, one in Austria, one in Switzerland, and one or more in England.

As to the possibilities of ramie in manufacture there seems to be no limit. Stuff goods for men's wear, upholstery, curtains, laces, and embroideries, plushes and velvets, stockings, underclothing, table damask, napkins, handkerchiefs, shirtings, sheetings, sail duck, carpets, cordage, fishing nets, and yarns and threads for various uses not enumerated. Even the Chinese recognize this wide utility, and while they manufacture the fiber from one variety of the plant into grass cloth and similar fabrics, they use another for fishing lines, nets, and the many useful products that may be classified under the general term *cordage*.

Regarding these various uses of ramie fiber in manufacture, however, M. Roux says we should not conclude that this textile is destined to be employed so largely. The cost of its preparation will always prevent its common use as a substitute for the textiles that can be more cheaply grown and prepared. He concludes that while it has the brilliancy, it has not the elasticity of wool and silk, nor the flexibility of cotton. But it will always be preferred for making articles requiring the strength to resist the wear and tear of washing or exposure to weather.

This faculty to imitate all other textiles is even one of the principal causes which have kept back the development of the ramie industry; and if, instead of launching out into a series of experiments, attention had been concentrated upon the exclusive manufacture of those articles to which the properties of the plant were peculiarly and naturally adapted, this industry would, probably, be in a more advanced condition than it is at present. The United States Department of Agriculture has held this position since its work in this field was begun. The folly of building up a ramie manufacturing industry on a false basis, that is, by employing the textile as a substitute for something else, is to be deprecated. The fiber should be used in those articles of economic necessity which would appear on the market *as ramie*, in order that any distinctive merit the textile may possess may become known, not only to the trade, but to the consumers of the product. Even then there will be an abundant demand for the textile, and for the waste fiber or combings, for use in mixing with other textiles, or for employment as out-and-out substitutes for them. Nor will the wearing qualities of these manufactures at all suffer through the substitution.

Ramie manufacture in our own country can hardly be said to have reached the commercial stage, though quite satisfactory results have been attained. The simpler forms of ramie fabrics were experimentally manufactured twenty years ago, but serious effort belongs to the present decade.

But it is needless to dwell on this phase of the industry, as successful growth and the machine question are the vital considerations. The spinning and weaving of ramie are no longer problems, and with these industries fairly established, as they are in Europe, improvements in machinery and processes to enhance the beauty of the products, to supply new forms of fabrics, and to reduce the cost of manufacture, will naturally follow, and the ramie industry will take its place with the linen industry and the other vast textile occupations which are such sources of wealth to the countries where they are carried on. Briefly summarizing the situation, the outlook is most hopeful.

FORESTRY FOR FARMERS.

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The following four chapters have been written with the view of aiding farmers who own small timber tracts or wood lots, or who wish to plant some part of their land to forest. This country varies so greatly in soil, climate, and flora that it is only possible, within the limits assigned for the present discussion, to outline general principles everywhere applicable. Nevertheless, wherever suggestions have approximated the laying down of rules of practice, the writer has had mainly in mind the conditions prevalent in our northeastern States. Moreover, for the reason already referred to, limitation of space, it has not been possible to give more than a comprehensive view, without much detail.

The succeeding chapters should be read connectedly, as they are more or less interdependent. The first treats of the behavior of a forest plant; the second, of the principles which should guide the planter in setting a crop; the third, of the manner in which a natural forest crop should be produced; and the fourth chapter points out how the crop should be managed afterwards in order to secure the best results in quantity and quality of material.

1. HOW TREES GROW.

Trees, like most other plants, originate from seed, build up a body of cell tissues, form foliage, flower, and fruit, and take up food material from the soil and air, which they convert into cellulose and other compounds, from which all their parts are formed. They rely, like other plants, upon moisture, heat, and light as the means of performing the functions of growth. Yet there are some peculiarities in their behavior, their life and growth, which require special attention on the part of a tree grower or forest planter, and these we shall briefly discuss.

FOOD MATERIALS AND CONDITIONS OF GROWTH.

Trees derive their food and solid substance in part from the air and in part from the soil. The solid part of their bodies is made up of cellulose, which consists largely of carbon (44 per cent of its weight), with hydrogen and oxygen added in almost the same proportions as in water. The carbon is derived from the carbonic acid of the air, which

enters into the leaves and, under the influence of light, air, and water, is there decomposed; the oxygen is exhaled; the carbon is retained and combined with elements derived from the water, forming compounds, such as starch, sugar, etc., which are used as food materials, passing down the tree through its outer layers to the very tips of the roots, making new wood all along the branches, trunk, and roots.

This process of food preparation, called "assimilation," can be carried on only in the green parts, and in these only when exposed to light and air; hence foliage, air, and light at the top are essential prerequisites for tree growth, and hence, other conditions being favorable, the more foliage and the better developed it is, and the more light this foliage has at its disposal for its work, the more vigorously will the tree grow.

In general, therefore, pruning, since it reduces the amount of foliage, reduces also, for the time, the amount of wood formed; and just so shading, reducing the activity of foliage, reduces the growth of wood.

SOIL CONDITIONS.

From the soil trees take mainly water, which enters through the roots and is carried through the younger part of the tree to the leaves, to be used in part on its passage for food and wood formation and in part to be given up to the air by transpiration.

In a vigorously growing tree the solid wood substance itself will contain half its weight in the form of water chemically combined, and the tree, in addition, will contain from 40 to 65 per cent and more of its dry weight in water mechanically or "hygroscopically" held. This last, when the tree is cut, very largely evaporates; yet well-seasoned wood still contains 10 to 12 per cent of such water. The weight of a green tree, a pine, for instance, is made up, in round numbers, of about 30 per cent of carbon and 70 per cent of water, either chemically or hygroscopically held, while a birch contains a still larger percentage of water.

The largest part of the water which passes through the tree is transpired—i. e., given off to the air in vapor. The amounts thus transpired during the season vary greatly with the species of tree, its age, the amount of foliage at work, the amount of light at its disposal, the climatic conditions (rain, temperature, winds, relative humidity), and the season. These amounts are, however, very large when compared with the quantity retained; so that while an acre of forest may store in its trees, say, 1,000 pounds of carbon, 15 to 20 pounds of mineral substances, and 5,000 pounds of water in a year, it will have transpired—taken up from the soil and returned to the air—from 500,000 to 1,500,000 pounds of water (one-quarter to one-half as much as agricultural crops).

Mineral substances are taken up only in very small quantities, and these are mostly the commoner sorts, such as lime, potash, magnesia, and nitrogen. These are carried in solution to the leaves, where they are used (as perhaps also on their passage through the tree), with a

part of the water, in food preparation. The main part of the mineral substances taken up remains, however, as the water transpires, in the leaves and young twigs, and is returned to the soil when the leaves are shed or when the tree is cut and the brush left to decompose and make humus.

Hence the improvement of the fertility of the soil by wood crops is explained, the minerals being returned in more soluble form to the soil; as also the fact that wood crops do not exhaust the soil of its minerals, provided the leaves and litter are allowed to remain on the ground.

For this reason there is no necessity of alternating wood crops, as far as their mineral needs are concerned; the same kind of trees can be grown on the same soil continuously, provided the soil is not allowed to deteriorate from other causes.

As the foliage can perform its work of food assimilation only when sufficient water is at its disposal, the amount of growth is also dependent not only on the presence of sufficient sources of supply, but also on the opportunity had by the roots to utilize the supply, and this opportunity is dependent upon the condition of the soil. If the soil is compact, so that the rain water can not penetrate readily, and runs off superficially, or if it is of coarse grain and so deep that the water rapidly sinks out of reach of the roots and can not be drawn up by capillary action, the water supply is of no avail to the plants; but if the soil is porous and moderately deep (depth being the distance from the surface to the impenetrable subsoil, rock, or ground water) the water not only can penetrate but also can readily be reached and taken up by the roots.

The moisture of the soil being the most important element in it for tree growth, the greatest attention must be given to its conservation and most advantageous distribution through the soil.

No trees grow to the best advantage in very dry or very wet soil, although some can live and almost thrive in such unfavorable situations. A moderately but evenly moist soil, porous and deep enough or fissured enough to be well drained, and yet of such a structure that the water supplies from the depths can readily be drawn up and become available to the roots—that is the soil on which all trees grow most thriftily.

The agriculturist procures this condition of the soil as far as possible by plowing, drainage, and irrigation, and he tries by cultivating to keep the soil from compacting again, as it does under the influence of the beating rain and of the drying out of the upper layers by sun and wind.

The forest grower can not rely upon such methods, because they are either too expensive or entirely impracticable. He may, indeed, plow for his first planting, and cultivate the young trees, but in a few years this last operation will become impossible and the effects of the first operation will be lost. He must, therefore, attain his object in another manner, namely, by shading and mulching the soil. The shading is

done at first by planting very closely, so that the ground may be protected as soon as possible from sun and wind, and by maintaining the shade well throughout the period of growth. This shade is maintained, if necessary, by more planting, and in case the main crop in later life thins out inordinately in the crowns or tops, or by the accidental death of trees, it may even become desirable to introduce an underbrush.

The mulching is done by allowing the fallen leaves and twigs to remain and decay, and form a cover of rich mold or humus. This protective cover permits the rain and snow waters to penetrate without at the same time compacting the soil, keeping it granular and in best condition for conducting water, and at the same time preventing evaporation at the surface.

The soil moisture, therefore, is best maintained by proper soil cover, which, however, is needful only in naturally dry soils. Wet soils, although supporting tree growth, do not, if constantly wet, produce satisfactory wood crops, the growth being very slow. Hence they must be drained and their water level sunk below the depth of the root system.

Irrigation is generally too expensive to be applied to wood crops, except perhaps in the arid regions, where the benefit of the shelter belt may warrant the expense.

Attention to favorable moisture conditions in the soil requires the selection of such kinds of trees as shade well for a long time, to plant closely, to protect the woody undergrowth (but not weeds), and to leave the litter on the ground as a mulch.

Different species, to be sure, adapt themselves to different degrees of soil moisture, and the crop should therefore be selected with reference to its adaptation to available moisture supplies.

While, as stated, all trees thrive best with a moderate and even supply of moisture, some can get along with very little, like the conifers, especially pines; others can exist even with an excessive supply, as the bald cypress, honey locust, some oaks, etc. The climate, however, must also be considered in this connection, for a tree species, although succeeding well enough on a dry soil in an atmosphere which does not require much transpiration, may not do so in a drier climate on the same soil.

In the selection of different kinds of trees for different soils, the water conditions of the soil should, therefore, determine the choice.

LIGHT CONDITIONS.

To insure the largest amount of growth, full enjoyment of sunlight is needed. But as light is almost always accompanied by heat and relative dryness of air, which demands water from the plant, and may increase transpiration from the leaves inordinately, making them pump too hard, as it were, young seedlings of tree species whose foliage is not built for such strains require partial shading for the first year or two. The conifers belong to this class.

In later life the light conditions exert a threefold influence on the development of the tree, namely, with reference to soil conditions, with reference to form development, and with reference to amount of growth.

The art of the forester consists in regulating the light conditions so as to secure the full benefit of the stimulating effect of light on growth, without its deteriorating influences on the soil and on form development.

As we have seen, shade is desirable in order to preserve soil moisture. Now, while young trees of all kinds, during the "brush" stage of development, have a rather dense foliage, as they grow older they vary in habit, especially when growing in the forest. Some, like the beech, the sugar maple, the hemlock, and the spruce, keep up a dense crown; others, like the chestnut, the oaks, the walnut, the tulip tree, and the white pine, thin out more and more, and when fully grown have a much less dense foliage; finally, there are some which do not keep up a dense shade for any length of time, like the black and honey locust, with their small, thin leaves; the catalpa, with its large but few leaves at the end of the branchlets only, and the larch, with its short, scattered bunches of needles. So we can establish a comparative scale of trees with reference to the amount of shade which they can give continuously, as densely foliaged and thinly foliaged, in various gradations. If we planted all beech or sugar maple, the desirable shading of the soil would never be lacking, while if we planted all locust or catalpa the sun would soon reach the soil and dry it out, or permit a growth of grass or weeds, which is worse, because these transpire still larger quantities of water than the bare ground evaporates or an undergrowth of woody plants would transpire. Of course, a densely foliaged tree has many more leaves to shed than a thinly foliaged one, and therefore makes more litter, which increases the favorable mulch cover of the soil. Another reason for keeping the ground well shaded is that the litter then decomposes slowly, but into a desirable humus, which acts favorably upon the soil, while if the litter is exposed to light, an undesirable, partly decomposed "raw" humus is apt to be formed.

Favorable soil conditions, then, require shade, while wood growth is increased by full enjoyment of light; to satisfy both requirements, mixed planting, with proper selection of shade-enduring and light-needing species, is resorted to.

As the different species afford shade in different degrees, so they require for their development different degrees of light. The dense foliage of the beech, with a large number of leaves in the interior of the crown, proves that the leaves can exist and perform their work with a small amount of light; the beech is a shade-enduring tree. The scanty foliage of the birches, poplars, or pines shows that these are light-needing trees; hence they are never found under the dense shade of the former, while the shade-enduring can develop satisfactorily

under the light shade of the thin-foliaged kinds. Very favorable soil conditions increase the shade endurance of the latter, and climatic conditions also modify their relative position in the scale.

All trees ultimately thrive best—i. e., grow most vigorously—in the full enjoyment of light, but their energy then goes into branching. Crowded together, with the side light cut off, the lower lateral branches soon die and fall, while the main energy of growth is put into the shaft and the height growth is stimulated. The denser shade of the shade-enduring kinds, if placed as neighbors to light-needing ones, is most effective in producing this result, provided that the light is not cut off at the top; and thus, in practice, advantage is taken of the relative requirements for light of the various species.[1]

The forester finds in close planting and in mixed growth a means of securing tall, clear trunks, free from knots, and he is able, moreover, by proper regulation of light conditions, to influence the form development, and also the quality of his crop, since slow growth and rapid growth produce wood of different character.

There are some species which, although light foliaged and giving comparatively little shade, are yet shade enduring—i. e., can subsist, although not develop favorably, under shade; the oaks are examples of this kind. Others, like the black cherry, bear a dense crown for the first twenty years, perhaps, seemingly indicating great shade endurance; but the fact that the species named soon clears itself of its branches and finally has a thin crown, indicates that it is light needing, though a good shader for the first period of its life. Others, again, like the catalpa, which is shady and shade enduring, as the difficulty with which it clears itself indicates, leaf out so late and lose their foliage so early that their shading value is thereby impaired. Black locust and honey locust, on the other hand, leave no doubt either as to their light-needing or their inferior shading quality.

That soil conditions and climatic conditions also modify crown development and shade endurance has been well recognized abroad, but in our country this influence is of much more importance on account of the great variation in those conditions. Thus the box elder, an excellent shader in certain portions of the West, is a failure as soil cover in others where it nevertheless will grow.

We see, then, that in determining the shading value as well as the shade endurance of one species in comparison with another, with reference to forestry purposes, not only soil and climate but also the character of foliage and its length of season must be considered.

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[1]This relation of the different species to varying light conditions, their comparative shading value and shade endurance, is one of the most important facts to be observed and utilized by the forester. European foresters have done this, but since they had to deal with only a few species and over a limited territory, they could quite readily classify their trees with reference to their shade endurance, and take it for granted that shade endurance and density of foliage or shading value were more or less identical. With our great wealth of useful species it will be necessary and profitable to be more exact in the classification.

PHYSIOLOGY OF TREE GROWTH.

As we have seen, root and foliage are the main life organs of the tree. The trunk and branches serve to carry the crown upward and expose it to the light, which is necessary in order to prepare the food and increase the volume of the tree, and also as conductors of food materials up and down between root and foliage. A large part of the roots, too, aside from giving stability to the tree, serve only as conductors of water and food material; only the youngest parts, the fibrous roots, beset with innumerable fine hairs, serve to take up the water and minerals from the soil. These fine roots, root hairs, and young parts are therefore the essential portion of the root system. A tree may have a fine, vigorous-looking root system, yet if the young parts and fibrous roots are cut off or allowed to dry out, which they readily do—some kinds more so than others—thereby losing their power to take up water, such a tree is apt to die. Under very favorable moisture and temperature conditions, however, the old roots may throw out new sprouts and replace the fibrous roots. Some species, like the willows, poplars, locusts, and others, are especially capable of doing so. All trees that "transplant easily" probably possess this capacity of renewing the fibrous roots readily, or else are less subject to drying out. But it may be stated as a probable fact that most transplanted trees which die soon after the planting do so because the fibrous roots have been curtailed too much in taking up, or else have been allowed to dry out on the way from the nursery or forest to the place of planting; they were really dead before being set. Conifers—pines, spruces, etc.—are especially sensitive; maples, oaks, catalpas, and apples will, in this respect, stand a good deal of abuse.

Hence, in transplanting, the first and foremost care of the forest grower, besides taking the sapling up with least injury, is the proper protection of its root fibers against drying out.

The water, with the minerals in solution, is taken up by the roots when the soil is warm enough, but to enable the roots to act they must be closely packed with the soil. It is conveyed mostly through the outer, which are the younger, layers of the wood of root, trunk, and branches to the leaves. Here, as we have seen, under the influence of light and heat it is in large part transpired and in part combined with the carbon into organic compounds, sugar, etc., which serve as food materials. These travel from the leaf into the branchlet, and down through the outer layers of the trunk to the very tips of the root, forming new wood all the way, new buds, which lengthen into shoots, leaves, and flowers, and also new rootlets. To live and grow, therefore, the roots need the food elaborated in the leaves, just as the leaves need the water sent up from the roots.

Hence the interdependence of root system and crown, which must be kept in proportion when transplanting. At least, the root system must be sufficient to supply the needs of the crown.

"SAP UP AND SAP DOWN."

The growing tree, in all its parts, is more or less saturated with water, and as the leaves, under the influence of sun and wind and atmospheric conditions generally transpire, new supplies are taken in through the roots and conveyed to the crown. This movement takes place even in winter, in a slight degree, to supply the loss of water by evaporation from the branches. In the growing season it is so active as to become noticeable; hence the saying that the sap is "up," or "rising," and when, toward the end of the season, the movement becomes less, the sap is said to be "down." But this movement of water is always upward; hence the notion that there is a stream upward at one season and in one part of the tree, and a stream downward at another season and perhaps in another part of the tree, is erroneous. The downward movement is of food materials, and the two movements of water upward and food downward take place simultaneously, and depend, in part at least, one upon the other, the food being carried to the young parts, wherever required, by a process of diffusion from cell to cell known as "osmosis."

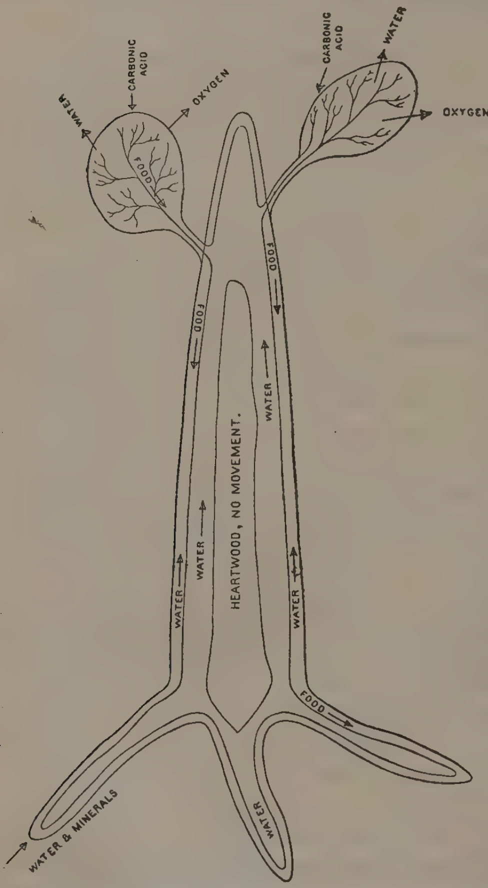

FIG. 116.—Physiological importance of different parts of the tree; pathways of water and food materials. (Schematic.)

These food materials are, by the life processes of the active cells, changed in chemical composition as need be, from sugar, which is soluble, into starch, which is insoluble, and back into sugar, and combined with nitrogenous substances to make the cell-forming material, protoplasm (fig. 116).

In the fall, when the leaves cease to elaborate food, both the upward and the downward movement, more or less simultaneously, come to rest (the surplus of food materials, as starch, and sometimes as sugar, being stored for the winter in certain cell tissues), to begin again simultaneously when in spring the temperature is high enough to reawaken

activity, when the stored food of last year is dissolved and started on its voyage. The exact manner in which this movement of water upward and food materials downward takes place, and the forces at work, are not yet fully understood, nor is there absolute certainty as to the parts of the tree in which the movement takes place. It appears, however, that while all the so-called "sapwood" is capable of conducting water (the heartwood is probably not), the most active movement of both water and food materials takes place in the cambium (the growing cells immediately beneath the bark) and youngest parts of the bark.

The deductions from these processes important to the planter are: That injury to the living bark or bast means injury to growth, if not destruction to life; that during the period of vegetation transplanting can be done only with great caution; that the best time to move trees is in the fall, when the leaves have dropped and the movement of water and food materials has mostly ceased, or in spring, before the movement begins again, the winter being objectionable only because of the difficulty of working the soil and of keeping the roots protected against frost. All things considered, spring planting, before activity in the tree has begun, is the best, although it is not impossible to plant at other times.

PROGRESS OF DEVELOPMENT.

Like the wheat or corn plant, the tree seed require as conditions for sprouting sufficient moisture, warmth, and air. Tree seeds, however, differ from grain in that most of the kinds lose their power of germination easily; with few exceptions (locust, pine, spruce), they can not be kept for any length of time.

The first leaves formed often differ essentially in shape from those of the mature tree, which may cause their being confounded with other plants, weeds, etc.

The little seedlings of many, especially the conifers, are quite delicate, and remain very small the first season; they need, therefore, the protecting shade of mother trees, or artificial shading, and also protection against weeds. The amount of light or shade given requires careful regulation for some of them; too much light and heat will kill them, and so will too much shade. This accounts for the failure of many seedlings that spring up in the virgin forest.

The planter, then, is required to know the nature and the needs of the various kinds of seeds and seedlings, so as to provide favorable conditions, when he will avoid sowing in the open field such as require the care which it is impracticable to give outside of the nursery.

GROWTH IN LENGTH AND RAMIFICATION.

While the stalk of wheat or corn grows for one season, exhausts itself in seed production, and then dies, the tree continues to grow from season to season, in length as well as in thickness. The growth

in length of shaft and branches proceeds from buds, made up of cell tissues, which can subdivide and lengthen into shoots, as well as make leaves. These buds are formed during summer, and when winter begins contain embryo leaves, more or less developed, under the protecting cover of scales (fig. 118). When spring stimulates the young plant to new activity, the buds swell, shed their scales, dis-

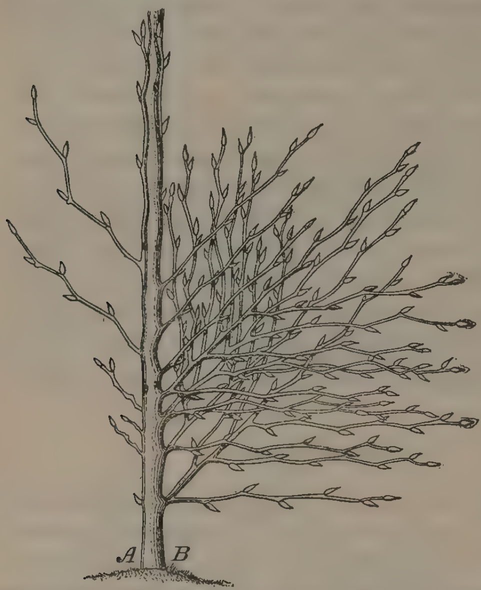

FIG. 117.—Bud development of beech. *B*, as it would be if all formed buds were to live; *A*, as it is, many buds failing to develop.

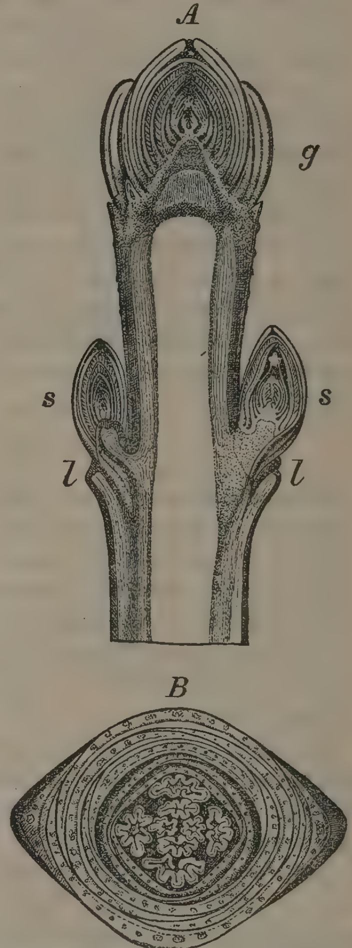

FIG. 118.—Buds of maple. *A*, longitudinal section through tip of a maple twig; *g*, end bud; *s*, lateral buds; *l*, scars of leaves of last season. *B*, cross section through end bud, showing folded leaves in center and scales surrounding them.

tend their cells, increasing their number by subdivision, and thus the leaves expand, and the bud lengthens into a shoot and twig. During the season new buds are formed, and the whole process repeats itself from year to year, giving rise to the ramification and height growth of the tree. The end buds being mostly stronger and better developed, the main axis of tree or branch increases more rapidly than the rest. All these buds originate from the youngest, central part of the shoot, the pith, and hence when the tree grows in thickness, enveloping the base of the limbs, their connection with the pith can always be traced. This is the usual manner of bud formation; in addition, so-called "adventitious" buds may be formed from the young living wood in later life, which are not connected with the pith. Such buds are those which develop into sprouts from the stump when the tree is

cut; also those which give rise to what are known as "water sprouts." Many buds, although formed, are, however, not developed at once, and perhaps not at all, especially as the tree grows older; these either die or remain "dormant," often for a hundred years, to spring into life when necessary (fig. 119).

The fact that each ordinary limb starts as a bud from the pith is an important one to the timber grower; it explains knotty timber and gives him the hint that in order to obtain clear timber the branches

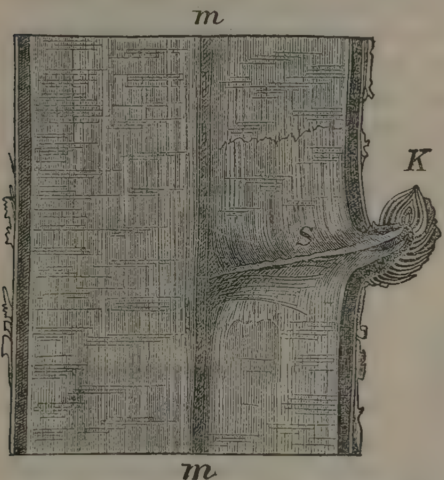

FIG. 119.—Dormant bud, *K*, on a 12-year old branch of beech. The bud is still capable of development and is connected with the pith, *mm*, of the stem by a fine trace of pith, *S*.

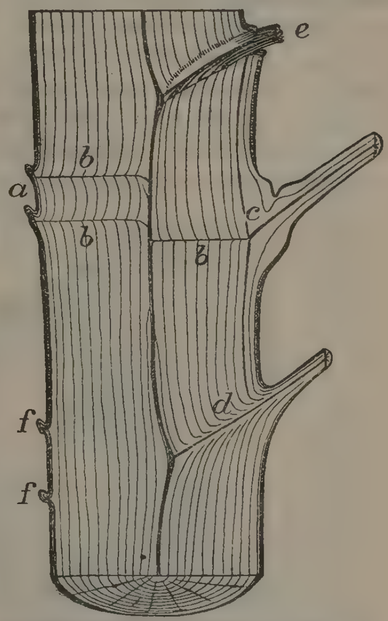

FIG. 120.—Section through a 12-year old stem of beech, showing manner of bud and limb formation. *a*, dormant buds; *b*, their trace of pith extending to the pith of the stem; *c*, a limb which started two years ago from a dormant bud; *d*, normal limb; *e*, a limb dead for four years; *f*, adventitious buds.

first formed must be soon removed, either by the knife or by proper shading, which kills the branches and thus "clears" the shaft.

The planter has it also in his power to influence the form development of the tree by removing some of the buds, giving thereby better chance to the remaining ones. This pruning of buds is, where practicable, often better practice than the pruning of limbs.

Since the tree does not grow in length except by its buds it is evident that a limb which started to grow at the height of 6 feet has its base always 6 feet from the ground, and if allowed to grow to size, must be surrounded by the wood which accumulates on the main stem or trunk. If a limb is killed and broken off early, only a slender stub composed entirely of rapidly decaying sapwood, is left, occasioning, therefore, only a small defect in the heart of the tree; but if left to grow to considerable age, the base of the limb is incased by the wood of the stem, which, when the tree is cut into lumber, appears as a knot.

The longer the limb has been allowed to grow, the farther out is the timber knotty and the thicker is the knot. If the limb remained alive, the knot is "sound," closely grown together with the fibers of the tree. I the limb died off, the remaining stub may behave in different ways. In pines it will be largely composed of heartwood, very resinous and durable; separated from the fibers of the overgrowing wood, it forms a "loose" knot, which is apt to fall out of a board, leaving a hole.

In broad-leaved trees, where no resin assists in the process of healing, the stub is apt to decay, and this decay, caused by the growth of fungi, is apt to penetrate into the tree (fig. 121). In parks and orchards, pruning is resorted to, and the cuts are painted or tarred to avoid the decay. In well-managed forests and dense woods in general, the light is cut off, the limb is killed when young and breaks away, the shaft "clears itself," and the sound trunk furnishes a good grade of material. The difference in development of the branch system, whether in full enjoyment of light, in open stand, or with the side light cut off, in dense position, is shown in the accompanying illustration (fig. 122).

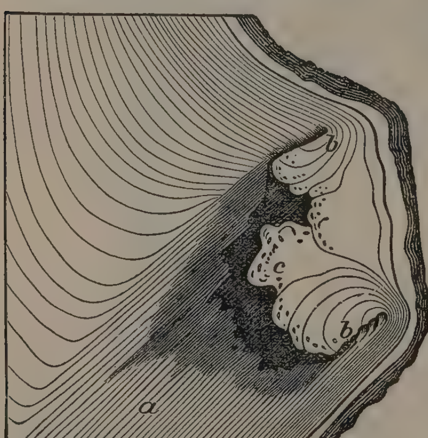

FIG. 121.—Section through a partly decayed knot in oak wood. *a*, wood of the knot; *b* and *c*, wood callus of the stem covering the wound; shaded portion, decayed wood; black part, a cavity remaining.

Both trees start alike; the one retains its branches, the other loses them gradually, the stubs being in time overgrown; finally the second has a clear shaft, with a crown concentrated at the top, while the first is beset with branches and branch stubs for its whole length (fig. 123).

When ripped open lengthwise, the interior exhibits the condition shown in figure 124, the dead parts of the knot being indicated in heavier shading. Since the branches grow in more or less regular whorls, several knots, stumps, or limbs are met every 6 to 24 inches through the entire stem.

Hence, in forest planting, trees are placed and kept for some time close together, in order to decrease the branching in the lower part of the tree and thus produce a clean bole and clear lumber.

GROWTH IN THICKNESS.

The young seedling and the young shoot of the older tree much resemble in interior structure that of any herbaceous plant, being composed of a large amount of pith, loose squarish cells, and a few bundles of long fibers symmetrically distributed about the center, the whole covered with a thin skin or epidermis. Each strand or bundle of

fibers, called fibro-vascular (fiber-vessel) bundles, consists of two kinds, namely, wood fibers on the inner side and bast fibers of different structure on the outer side. Between these two sets of fibers, the bast and the wood, there is a row of cells which form the really active, growing part of the plantlet, the cambium. The cambium cells are actively subdividing and expanding, giving off wood cells to the interior and bast cells to the exterior, and extending at the same time sidewise, until at the end of the season not only are the wood and bast portions increased in lines radiating from the center, but the cambium layer, the wood cells, and the bast cells of all the bundles (scattered at the beginning) join at the sides to form a complete ring, or rather hollow cylinder, around the central pith. Only here and there the pith cells remain, interrupting the wood cylinder and giving rise to the system of cells known as medullary rays. The cross section now shows a comparatively small amount of pith and bast or bark and a larger body of strong wood fibers. The new shoot at the end, to be sure, has the same appearance and arrangement as the young plantlet had, the pith preponderating, and the continuous cylinder of cambium, bast, and wood being separated into strands or bundles.

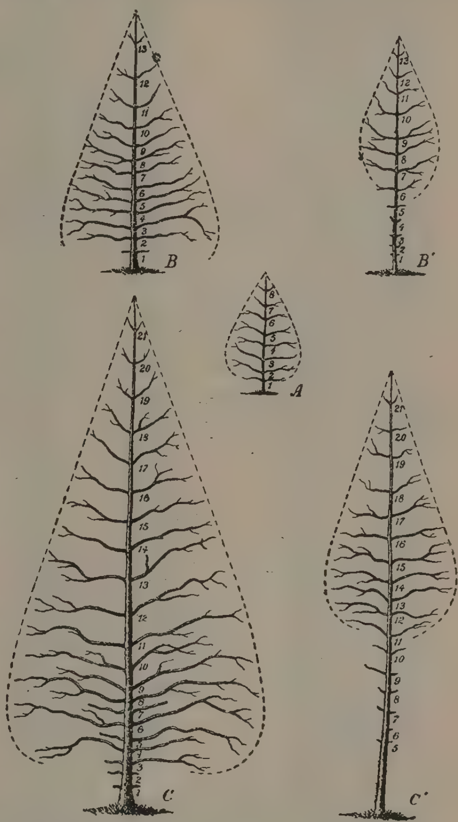

FIG. 122.—Development in and out of the forest. *A*, young tree alike in both cases; *B* and *C*, successive stages of tree grown in the open; *B′* and *C′*, corresponding stages of the tree grown in the forest. Numbers refer to annual growth in height.

During the season, through the activity of the cambial part of the bundles, the same changes take place in the new shoot as did the previous year in the young seedling, while at the same time the cambium in the yearling part also actively subdivides, forming new wood and bast cells, and thus a second ring, or rather cylinder, is formed. The cambium of the young shoot is always a continuation of that of the ring or cylinder formed the year before, and this cambium cylinder always keeps moving outward, so that at the end of the season, when activity ceases, it is always the last minute layer of cells on the outside of the wood, between wood proper and

bark. It is here, therefore, that the life of the tree lies, and any injury to the cambium must interfere with the growth and life of the tree.

The first wood cells which the cambium forms in the spring are usually or always of a more open structure, thin walled, and with a large opening or "lumen," comparable to a blown-up paper bag; so large, in fact, sometimes, is the "lumen" that the width of the cells can be seen on a cross section with the naked eye, as, for instance, in oak, ash, elm, the so-called "pores" are this open wood formed in spring. The cells, which are formed later in summer, have mostly thick walls, are closely crowded and compressed, and show a very small opening or "lumen," being comparable, perhaps, to a very thick wooden box. They appear in the cross section not only denser but of a deeper color, on account of their crowded, compressed condition and thicker walls. Since at the beginning of the next season again thin-walled cells with wide openings or lumina are formed, this difference in the appearance of "spring wood" and "summer wood" enables us to distinguish the layer of wood formed each year. This "annual ring" is more conspicuous in some kinds than in others.

FIG. 123.—Trees in and out of the forest. *D*, tree grown in the open; *D'*, tree grown in the forest.

In the so-called "ring porous" woods, like oak, ash, elm, the rings are easily distinguished by the open spring wood; in the conifers, especially pines, by the dark-colored summer wood; while in maple, birch, tulip, etc., only a thin line of flattened, hence darker and regularly aligned, summer cells, often hardly recognizable, distinguishes the rings from each other. Cutting through a tree, therefore, we can not only ascertain its age by counting its annual layers in the cross section, but also determine how much wood is formed each year (fig. 125). We

can, in fact, retrace the history of its growth, the vicissitudes through which it has passed, by the record preserved in its ring growth.

To ascertain the age of a tree correctly, however, we must cut so near to the ground as to include the growth of the first year's little plantlet; any section higher up shows as many years too few as it took the tree to reach that height.

This annual-ring formation is the rule in all countries which have distinct seasons of summer and winter and temporary cessation of growth. Only exceptionally a tree may fail to make its growth throughout its whole length on account of loss of foliage or other causes; and occasionally, when its growth has been disturbed during the season, a "secondary" ring, resembling the annual ring, and distinguishable only by the expert, may appear and mar the record.

To the forest planter this chapter on ring growth is of great importance, because not only does this feature of tree life afford the means of watching the progress of his crop, calculating the amount of wood formed, and therefrom determining when it is most profitable for him to harvest (namely, when the annual or periodic wood growth falls below a certain amount), but since the proportion of summer wood and spring wood determines largely the quality of the timber, and since he has it in his power to influence the preponderance of the one or other by adaptation of species to soils and by their management, ring growth furnishes an index for regulating the quality of his crop.

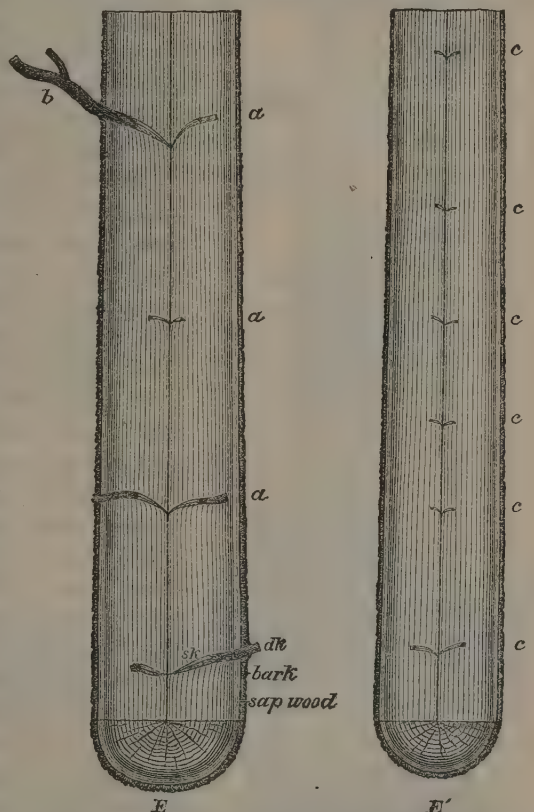

FIG. 124.—Sections of logs showing the relative development of knots. *E*, from tree grown in the open; *E′*, from tree grown in a dense forest; *a* and *c*, whorls of knots; *b*, dead limb; *sk*, "sound knot;" *dk*, "dead knot."

FORM DEVELOPMENT

If a tree is allowed to grow in the open, it has a tendency to branch, and makes a low and spreading crown. In order to lengthen its shaft and to reduce the number of branches it is necessary to narrow its

growing space, to shade its sides so that the lower branches and their foliage do not receive light enough to perform their functions. When the side shade is dense enough, these branches die and finally break off under the influence of winds and fungous growth; wood then forms over the scars and we get a clean shaft which carries a crown high up beyond the reach of shade from neighbors.

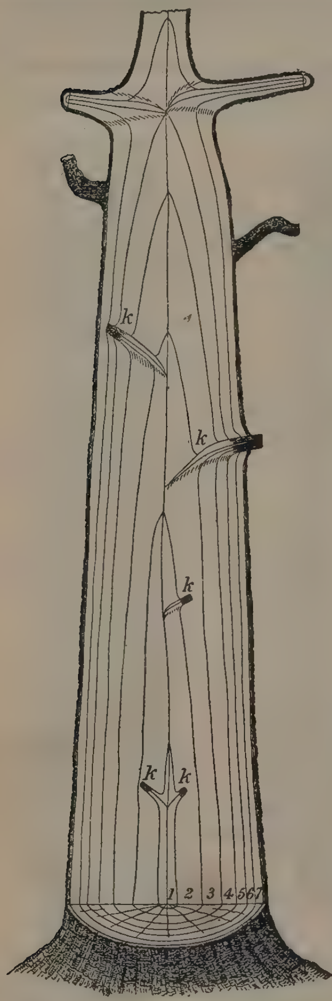

FIG. 125.—Scheme to illustrate the arrangement of annual growth. 1, 2, 3, etc., represent the parts of the stem grown during the first, second, third, etc., twenty years of the life of the tree. *k*, knots; the shaded part of each is the "dead knot" of lumber.

The branches being prevented from spreading out, the shaft is forced to grow upward, and hence, when crowded by others, trees become taller and more cylindrical in form, while in the open, where they can spread, they remain lower and more conical in form (figs. 126, 127).

There are, to be sure, different natural types of development, some, like the walnuts, oaks, beeches, and the broad-leafed trees generally, having greater tendency to spread than others, like spruces, firs, and conifers in general, which lengthen their shaft in preference to spreading, even in the open. This tendency to spreading is also influenced by soil conditions and climate, as well as by the age of the tree. When the trees cease to grow in height, their crowns broaden, and this takes place sooner in shallow soils than in deep, moist ones; but the tendency can be checked and all can be made to develop the shaft at the expense of the branches by proper shading from the sides.

It follows that the forest planter, who desires to produce long and clean shafts and best working quality of timber, must secure and maintain side shade by a close stand, while the landscape gardener, who desires characteristic form, must maintain an open stand and full enjoyment of light for his trees.

Now, as we have seen, different species afford different amounts of shade, and in proportion to the shade which they afford can they endure shade. The beech or sugar maple or spruce, which maintain a large amount of foliage under the dense shade of their own crown, show that their leaves can live and functionate with a small amount of light. They are shade-enduring trees. On the other hand,

the black walnut, the locust, the catalpa, the poplars, and the larch show by the manner in which their crowns thin out, the foliage being confined to the ends of the branches, that their leaves require more light—they are light-needing trees; so that the scale which arranges the trees according to the amount of shade they exert serves also to measure their shade endurance.

In making, therefore, mixed plantations, the different kinds must be so grouped and managed that the shady trees will not outgrow and overtop the light-needing; the latter must either have the start of the former or must be quicker growers.

RATE OF GROWTH.

Not only do different species grow more or less rapidly in height and girth, but there is in each species a difference in the rate of growth during different periods of life, and a difference in the persistence of growth.

It stands to reason that trees grow differently in different soils and situations, and hence we can not compare different species with respect to their rate of growth except as they grow under the same conditions.


FIG. 126.—Oak tree grown in the open.


FIG. 127.—Maple tree grown in the forest.

Thus the black walnut may grow as fast as or faster than the ash on a rich, deep, moist, warm soil, but will soon fall to the rear in a wetter, colder, and shallower soil.

Given the same conditions, some species will start on a rapid upward growth at once, like the poplars, aspen, locust, and silver maple, making rapid progress (the most rapid from their tenth to their fifteenth year), but decreasing soon in rate and reaching their maximum height early. Others, like the spruce, beech, and sugar maple, will begin slowly, often occupying several, sometimes as many as 10 to 15, years before they appear to grow at all, their energy all going into root growth. Then comes a period of more and more accelerated growth, which reaches its maximum rate at 25 or 30 years; and when the cottonwood or aspen

has reached the end of its growth in height the spruce or pine is still at its best rate, and continues to grow for a long time at that rate; in later life the rate decreases, yet height growth sometimes does not cease altogether for centuries. As a rule, the light-needing species are the ones which show the rapid height growth at the start, while the shade-enduring are slow at the start, but persistent growers.

This fact is important in explaining the alternations of forest growth in nature; the persistent shade-enduring species crowd out the light-needing, and the latter rapidly take possession of any openings that fire or storm has made. It is also important with reference to the management of wood crops and starting of mixed plantations; the light-needing species must be mixed only with such shade-enduring species as are slower growers than themselves.

The diameter growth shows also periodic changes in its rate, and is, of course, influenced in the same way by soil, climate, and light conditions, as the height growth.

In the juvenile or brush stage, lasting 6 to 10 years in light-needing and 20 to 40 years in shade-enduring species, the diameter grows comparatively little, all energy being directed to height growth and root growth. When the crown has been definitely formed, more food material is available for wood formation, and the increase in foliage is accompanied by a more rapid increase of trunk diameter; in favorable situations, the highest rate occurs between the fortieth and sixtieth years; in the poorer situations, between the fiftieth and eightieth years, which rate continues for some time. Then comes a period of slower rate, which finally in old age dwindles down almost to zero.

But neither the diameter growth nor the width of the annual rings alone tells us directly what amount of wood is forming. The outer rings, being laid over a larger circumference, although thinner than the preceding rings, may yet have greater cubic contents. The statements of diameter growth are, therefore, misleading if we are interested in knowing how much wood is forming.

Accordingly the growth in volume must be considered separately, as determined by the enlargement of the cross-section area and the height. The growth in volume or mass accretion is quite small in young trees, so that when wood is cut young the smallest amount of crop per year is harvested, while, if it is allowed to grow, an increase more than proportionate to the number of years may be obtained.

Only when the tree has a fully developed crown does it begin to make much wood. Its volume growth progresses then at compound interest, and continues to do so for decades, and sometimes for a century or more.

On poorer sites the rate is slower, but remains longer on the increase, while on good sites the maximum rate is soon reached.

Of course, in a forest, where light conditions are not most favorable, because form development and soil conditions require shade, the total wood formation is less than in an isolated tree, favorably placed. Just

so the dominant trees in a forest—i. e., those which have their crowns above all others—show, of course, the advantage they have over the inferior trees which are suffering from the shade of their neighbors.

Finally, if we would take into consideration an entire forest growth, and determine, for instance, how much wood an acre of such forest produces at different periods, we must not overlook the fact that the number of trees per acre changes as the trees grow older. Some of them are overshaded and crowded out by the others, so that a young growth of spruce might start with 100,000 little seedlings to the acre, of which in the twentieth year only 10,000 would be alive, while in the fortieth year the number would be reduced to 1,200, and in the hundredth year to 280. Hence the rate of growth of any single tree gives no idea of what the acre of forest will do.

Thus, while a single good white pine might grow the fastest in volume when about one hundred years old, then making wood at the rate of, say, 1.5 cubic feet per year, an acre of pine on good soil, containing about 1,600 trees, may make the most wood in the thirtieth year, then growing at the rate of 170 cubic feet per acre, while in the hundredth year the rate would not exceed 70 cubic feet; and an acre of pine in a poorer location, with about 1,400 trees, may make the most wood in the fortieth year, at the rate of 100 cubic feet per acre.

From the consideration of the relation of light conditions to soil conditions, to form development, and to rate of growth, we may make the following deductions of interest to the forest planter:

In order to secure the best results in wood production, in quantity and quality, at the same time preserving favorable soil conditions, the forest should be composed of various species, a mixture of light-needing and shade-enduring kinds. The light-needing ones should be of quicker growth; the shady ones, in larger numbers, should be slower growers. For the first fifteen to twenty-five years the plantation should be kept as dense as possible, to secure clear shafts and good growth in height; then it should be thinned, to increase crown development and diameter growth; the thinning, however, is not to be so severe that the crowns can not close up again in two or three years; the thinning is to be repeated again and again, always favoring the best developed trees.

REPRODUCTION.

All trees reproduce themselves naturally from seed. Man can secure their reproduction also from cuttings or layers; and some kinds can reproduce themselves by shoots from the stump when the parent tree has been cut. This latter capacity is possessed in a varying degree by different species; chestnuts, oaks, elms, maples, poplars, and willows are most excellent sprouters; most conifers do not sprout at all, and the shoots of those that do sprout soon die (Sequoia or California redwood seems to be an exception). Sprouts of broad-leafed trees develop differently from seedlings, growing very rapidly at first, but soon lessening in the rate of growth and never attaining the height and perhaps not

the diameter of trees grown from the seed; they are also shorter lived. With age the stumps lose their capacity for sprouting. To secure best results, the parent tree should be cut close to the ground in early spring, avoiding severe frost, and a sharp cut should be made which will not sever the bark from the trunk.

Not all trees bear seed every year, and plentiful seed production, especially in a forest, occurs, as a rule, periodically. The periods differ with species, climate, and season.

Not all seeds can germinate, and in some species the number of seeds that can germinate is very small, and they lose their power of germination when kept a few hours, like the willows. Others, if kept till they have become dry, will "lie over" in the soil a year or more before germinating. The same thing will occur if they are covered too deep in the soil, provided they germinate at all under such conditions.

In order to germinate, seeds must have warmth, air, and moisture. The preparation of a seed bed is, therefore, necessary in order to supply these conditions in most favorable combination. In the natural forest millions of seeds rot or dry without sprouting, and millions of seedlings sprout, but soon perish under the too dense shade of the mother trees.

Man, desiring to reproduce a valuable wood crop, can not afford to be as lavish as nature, and must therefore improve upon nature's methods, making more careful preparation for the production of his crop, either by growing the seedlings in nurseries and transplanting them, or else by cutting away the old growth in such a manner as to secure to the young self-grown crop better chances for life and development.

2. HOW TO PLANT A FOREST

Forest planting and tree planting are two different things. The orchardist, who plants for fruit; the landscape gardener, who plants for form; the roadside planter, who plants for shade, all have objects in view different from that of the forest planter, and therefore select and use their plant material differently. They deal with single individual trees, each one by itself destined for a definite purpose. The forester, on the other hand, plants a crop like the farmer; he deals not with the single seed or plant, but with masses of trees; the individual tree has value to him only as a part of the whole. It may come to harvest for its timber, or it may not come to harvest, and yet have answered its purpose as a part of the whole in shading the ground, or acting as nurse or "forwarder" as long as it was necessary.

His object is not to grow trees, but to produce wood, the largest amount of the best quality per acre, whether it be stored in one tree or in many, and his methods must be directed to that end.

As far as the manner of setting out plants or sowing seeds is concerned, the same general principles and the same care in manipulation are applicable as in any other planting, except as the cost of operating

on so large a scale may necessitate less careful methods than the gardener or nurseryman can afford to apply; the nearer, however, the performance of planting can be brought to the careful manner of the gardener, the surer the success. The principles underlying such methods have been discussed in the chapter "How trees grow;" in the present chapter it is proposed to point out briefly the special considerations which should guide the forest planter in particular.

WHAT TREES TO PLANT.

Adaptability to climate is the first requisite in the species to be planted.

It is best to choose from the native growth of the region which is known to be adapted to it. With regard to species not native, the reliance must be placed upon the experience of neighboring planters and upon experiment (at first on a small scale), after study of the requirements of the kinds proposed for trial.

Adaptation must be studied, not only with reference to temperature ranges and rainfall, but especially with reference to atmospheric humidity and requirements of transpiration.

Many species have a wide range of natural distribution, and hence of climatic adaptation. If such are to be used, it is important to secure seeds from that part of the range of natural distribution where the plants must be hardiest, i. e., the coldest and driest region in which it occurs, which insures hardy qualities in the offspring. For instance, the Douglas spruce from the humid and evenly tempered Pacific Slope will not be as hardy as that grown from seed collected on the dry and frigid slopes of the Rockies. Lack of attention to this requisite accounts for many failures. It must also be kept in mind that, while a species may be able to grow in another than its native climate, its wood may not there have the same valuable qualities which it develops in its native habitat.

Adaptability to soil must be studied less with reference to mineral constituents than to physical condition. Depth and moisture conditions, and the structure of the soil, which influences the movement of water in it, are the most important elements. While all trees thrive best in a moist to "fresh" soil of moderate depth (from 2 to 4 feet) and granular structure, some can adapt themselves to drier or wetter, shallow, and compact soils. Fissures in rocks into which the roots can penetrate often stand for depth of soil, and usually aid in maintaining favorable moisture conditions. In soils of great depth (i. e., from the surface to the impenetrable subsoil) and of coarse structure water may drain away so fast as not to be available to the roots.

Soil moisture must always be studied in conjunction with atmospheric moisture; for, while a species may thrive in an arid soil, when the demands of transpiration are not great, it may not do so when aridity

of atmosphere is added. Trees of the swamp are apt to be indifferent to soil moisture and to thrive quite well, if not better, in drier soils.

Adaptability to site.—While a species may be well adapted to the general climatic conditions of a region, and in general to the soil, there still remains to be considered its adaptability to the particular "site," under which term we may comprise the total effect of general climate, local climate, and soil. The general climatic conditions are locally influenced, especially by the slope, exposure, or aspect, and the surroundings. Thus we know that eastern exposures are more liable to frost, western exposures more liable to damage from winds, southern more apt to be hot and to dry out, and northern to be cooler and damper, having in consequence a shorter period of vegetation. Hollows and lowlands are more exposed to frosts and more subject to variations in soil moisture, etc.

Hence for these various situations it is advisable to select species which can best withstand such local dangers.

The use value, or utility, of the species is next to be considered. This must be done with reference to the commercial and domestic demand, and the length of time it takes the species to attain its value. The greater variety of purposes a wood may serve—i. e., the greater its general utility—and the sooner it attains its use value the better. White pine for the northeastern States as a wood is like the apple among fruits, making an all-round useful material in large quantities per acre in short time. Tulip poplar, applicable to a wider climatic range, is almost as valuable, while oak, ash, and hickory are standard woods in the market. Other woods are of limited application. Thus the black locust, which grows most quickly into useful posts, has only a limited market, much more limited than it should have; hickory soon furnishes valuable hoop poles from the thinnings, and later the best wagon material, not, however, large quantities in a short time; while black walnut of good quality is very high in price, the market is also limited, and the dark color of the heartwood, for which it is prized, is attained only by old trees. The black cherry, used for similar purposes, attains its value much sooner.

By planting various species together, variety of usefulness may be secured and the certainty of a market increased.

The forest value of the species is only in part expressed by its use value. As has been shown in another place, the composition of the crop must be such as to insure maintenance of favorable soil conditions, as well as satisfactory development of the crop itself. Some species, although of high use value, like ash, oak, etc., are poor preservers of soil conditions, allowing grass and weeds to enter the plantation and to deteriorate the soil under their thin foliage. Others, like beech, sugar maple, box elder, etc., although of less use value, being dense foliaged and preserving a shady crown for a long time, are of great forest value as soil improvers.

Again, as the value of logs depends largely on their freedom from knots, straightness, and length, it is of importance to secure these qualities. Some valuable species, if grown by themselves, make crooked trunks, do not clean their shafts of branches, and are apt to spread rather than lengthen. If planted in close companionship with others, they are forced by these "nurses or forwarders" to make better growths and clean their shafts of branches.

Furthermore, from financial considerations, it is well to know that some species develop more rapidly and produce larger quantities of useful material per acre than others; thus the white pine is a "big cropper," and, combining with this a tolerably good shading quality, and being in addition capable of easy reproduction, it is of highest "forest value."

Hence, as the object of forestry is to make money from continued wood crops, use value and forest value must both be considered in the selection of materials for forest planting.

Mutual relationship of different species, with reference especially to their relative height growth and their relative light requirements, must be considered in starting a mixed plantation.

Mixed forest plantations (made of several kinds) have so many advantages over pure plantations (made of one kind) that they should be preferred, except for very particular reasons. Mixed plantations are capable of producing larger quantities of better and more varied material, preserve soil conditions better, are less liable to damage from winds, fires, and insects, and can be more readily reproduced.

The following general rules should guide in making up the composition of a mixed plantation:

a. Shade-enduring kinds should form the bulk (five-eighths to seven-eighths) of the plantation, except on specially favored soils where no deterioration is to be feared from planting only light-needing kinds, and in which case these may even be planted by themselves.

b. The light-needing trees should be surrounded by shade-enduring of slower growth, so that the former may not be overtopped, but have the necessary light and be forced by side shade to straight growth.

c. Shade-enduring species may be grown in admixture with each other when their rate of height growth is about equal, or when the slower-growing kind can be protected against the quicker-growing (for instance, by planting a larger proportion of the former in groups or by cutting back the latter).

d. The more valuable timber trees which are to form the main crop should be so disposed individually, and planted in such numbers among the secondary crop or nurse crop, that the latter can be thinned out first without disturbing the former.

Where a plantation of light-foliaged trees has been made (black walnut, for instance), it can be greatly improved by "underplanting" densely with a shade-enduring kind, which will choke out weed growth, improve the soil, and thereby advance the growth of the plantation.

The selection and proper combination of species with reference to this mutual relationship to each other and to the soil are the most important elements of success.

Availability of the species also still needs consideration in this country; for, although a species may be very well adapted to the purpose in hand, it may be too difficult to obtain material for planting in quantity or at reasonable prices. While the beech is one of the best species for shade endurance, and hence for soil cover, seedlings can not be had as yet in quantity. Western conifers, although promising good material for forest planting, are at present too high priced for general use. Some eastern trees can be secured readily—either their seed or seedlings—from the native woods; others must be grown in nurseries before they can be placed in the field.

Whether to procure seeds or plants, and if the latter, what kind, depends upon a number of considerations. The main crop, that which is to furnish the better timber, had best be planted with nursery-grown plants, if of slow-growing kinds, perhaps once transplanted, with well-developed root systems, the plants in no case to be more than 2 to 3 years old. The secondary or nurse crop may then be sown or planted with younger and less costly material taken from the woods or grown in seed beds, or else cuttings may be used.

In some localities—for instance, the Western plains—the germinating of seeds in the open field is so uncertain, and the life of the young seedlings for the first year or two so precarious, that the use of seeds in the field can not be recommended. In such locations careful selection and treatment of the planting material according to the hardships which it must encounter can alone insure success.

Seedlings from 6 to 12 inches high furnish the best material. The planting of large-sized trees is not excluded, but is expensive and hence often impracticable, besides being less sure of success, since the larger-sized tree is apt to lose a greater proportion of its roots in transplanting.

METHODS OF PLANTING.

Preparation of soil is for the purpose of securing a favorable start for the young crop; its effects are lost after the first few years. Most land that is to be devoted to forest planting does not admit of as careful preparation as for agricultural crops, nor is it necessary where the climate is not too severe and the soil not too compact to prevent the young crop from establishing itself. Thousands of acres in Germany are planted annually without any soil preparation, yearling pine seedlings being set with a dibble in the unprepared ground. This absence of preparation is even necessary in sandy soils, like that encountered in the sandhills of Nebraska, which may, if disturbed, be blown out and shifted. In other cases a partial removal of a too rank undergrowth or soil cover and a shallow scarifying or hoeing is resorted to, or else furrows are thrown up and the trees set out in them.

In land that has been tilled, deep plowing (10 to 12 inches) and thorough pulverizing give the best chances for the young crop to start. For special conditions, very dry or very moist situations, special

methods are required. The best methods for planting in the semiarid regions of the far West have not yet been developed. Thorough cultivation, as for agricultural crops, with subsequent culture, is successful, but expensive. A plan which might be tried would consist in breaking the raw prairie in June and turning over a shallow sod, sowing a crop of oats or alfalfa, harvesting it with a high stubble, then opening furrows for planting and leaving the ground between furrows undisturbed, so as to secure the largest amount of drainage into the furrows and a mulch between the rows.

The time for planting depends on climatic and soil conditions and the convenience of the planter. Spring planting is preferable except in southern latitudes, especially in the West, where the winters are severe and the fall apt to be dry, the soil therefore not in favorable condition for planting.

The time for fall planting is after the leaves have fallen; for spring planting, before or just when life begins anew. In order to be ready in time for spring planting, it is a good practice to take up the plants in the fall and "heel them in" over winter (covering them, closely packed, in a dry trench of soil). Conifers can be planted later in spring and earlier in fall than broad-leafed trees.

The density of the trees is a matter in which most planters fail. The advantages of close planting lie in the quicker shading of the soil, hence the better preservation of its moisture and improved growth and form development of the crop. These advantages must be balanced against the increased cost of close planting. The closer the planting, the sooner will the plantation be self-sustaining and the surer the success.

If planted in squares, or, better still, in quincunx order (the trees in every other row alternating at equal distances), which is most desirable on account of the more systematic work possible and the more complete cover which it makes, the distance should not be more than 4 feet, unless for special reasons and conditions, while 2 feet apart is not too close, and still closer planting is done by nature with the best success.

The following numbers of trees per acre are required when planting at distances as indicated:

1½ by 1½ feet	19,360	2 by 4 feet	5,445
1½ by 2 feet	14,520	3 by 3 feet	4,840
2 by 2 feet	10,890	3 by 4 feet	3,630
2 by 3 feet	7,260	4 by 4 feet	2,722

To decrease expense, the bulk of the plantation may be made of the cheapest kinds of trees that may serve as soil cover and secondary or nurse crop, the main crop of from 300 to 600 trees to consist of better kinds, and with better planting material, mainly of light-needing species. These should be evenly disposed through the plantation, each closely surrounded by the nurse crop. It is, of course, understood that not all trees grow up; a constant change in numbers by the death (or else timely removal) of the overshaded takes place, so that the final crop shows at 100 years a close cover, with hardly 300 trees to the acre.

After-culture is not entirely avoidable, especially under unfavorable climatic conditions, and if the planting was not close enough. Shallow cultivation between the rows is needed to prevent weed growth and to keep the soil open, until it is shaded by the young trees, which may take a year with close planting and two or three years with rows 4 by 4 feet apart, the time varying also with the species.

It is rare that a plantation succeeds in all its parts; gaps or fail places occur, as a rule, and must be filled in by additional planting as soon as possible, if of larger extent than can be closed up in a few years by the neighboring growth.

When the soil is protected by a complete leaf canopy, the forest crop may be considered as established, and the after-treatment will consist of judicious thinning.

3. HOW TO TREAT THE WOOD LOT.

In the northeastern States it is the custom to have connected with the farm a piece of virgin woodland, commonly called the wood lot. Its object primarily is to supply the farmer with the firewood, fence material, and such dimension timbers as he may need from time to time for repairs on buildings, wagons, etc.

As a rule, the wood lot occupies, as it ought to, the poorer part of the farm, the rocky or stony, the dry or the wet portions, which are not well fitted for agricultural crops. As a rule, it is treated as it ought not to be, if the intention is to have it serve its purpose continuously; it is cut and culled without regard to its reproduction.

As far as firewood supplies go, the careful farmer will first use the dead and dying trees, broken limbs, and leavings, which is quite proper. The careless man avoids the extra labor which such material requires, and takes whatever splits best, no matter whether the material could be used for better purposes or not.

When it comes to the cutting of other material, fence rails, posts, or dimension timber, the general rule is to go into the lot and select the best trees of the best kind for the purpose. This looks at first sight like the natural, most practical way of doing. It is the method which the lumberman pursues when he "culls" the forest, and is, from his point of view perhaps, justifiable, for he only desires to secure at once what is most profitable in the forest. But for the farmer, who proposes to use his wood lot continuously for supplies of this kind, it is a method detrimental to his object, and in time it leaves him with a lot of poor, useless timber which encumbers the ground and prevents the growth of a better crop.

Our woods are mostly composed of many species of trees; they are mixed woods. Some of the species are valuable for some special purposes, others are applicable to a variety of purposes, and again others furnish but poor material for anything but firewood, and even for that use they may not be of the best.

Among the most valuable in the northeastern woods we should mention the white pine—king of all—the white ash, white and chestnut oak, hickories, tulip tree, black walnut, and black cherry, the last three being now nearly exhausted; next, spruce and hemlock, red pine, sugar maple, chestnut, various oaks of the black or red oak tribe, several species of ash and birch, black locust; lastly, elms and soft maples, basswood, poplars, and sycamore.

Now, by the common practice of culling the best it is evident that gradually all the best trees of the best kinds are taken out, leaving only inferior trees or inferior kinds—the weeds among trees, if one may call them such—and thus the wood lot becomes well-nigh useless.

It does not supply that for which it was intended; the soil, which was of little use for anything but a timber crop before, is still further deteriorated under this treatment, and being compacted by the constant running of cattle, the starting of a crop of seedlings is made nearly impossible. It would not pay to turn it into tillage ground or pasture; the farm has by so much lost in value. In other words, instead of using the interest on his capital, interest and capital have been used up together; the goose that laid the golden egg has been killed.

This is not necessary if only a little system is brought into the management of the wood lot and the smallest care is taken to avoid deterioration and secure reproduction.

IMPROVEMENT CUTTINGS.

The first care should be to improve the crop in its composition. Instead of culling it of its best material, it should be culled of its weeds, the poor kinds, which we do not care to reproduce, and which, like all other weeds, propagate themselves only too readily. This weeding must not, however, be done all at once, as it could be in a field crop, for in a full-grown piece of woodland each tree has a value, even the weed trees, as soil cover.

The great secret of success in all crop production lies in the regulating of water supplies; the manuring in part and the cultivating entirely, as well as drainage and irrigation, are means to this end. In forestry these means are usually not practicable, and hence other means are resorted to. The principal of these is to keep the soil as much as possible under cover, either by the shade which the foliage of the tall trees furnishes, or by that from the underbrush, or by the litter which accumulates and in decaying forms a humus cover, a most excellent mulch.

A combination of these three conditions, viz, a dense crown cover, woody underbrush where the crown cover is interrupted, and a heavy layer of well-decomposed humus, gives the best result. Under such conditions, first of all, the rain, being intercepted by the foliage and litter, reaches the ground only gradually, and therefore does not compact the soil as it does in the open field, but leaves it granular and open, so that the water can readily penetrate and move in the soil. Secondly, the surface evaporation is considerably reduced by the shade

and lack of air circulation in the dense woods, so that more moisture remains for the use of the trees. When the shade of the crowns overhead (the so-called "crown cover," or "canopy,") is perfect, but little undergrowth will be seen; but where the crown cover is interrupted or imperfect, an undergrowth will appear. If this is composed of young trees, or even shrubs, it is an advantage, but if of weeds, and especially grass, it is a misfortune, because these transpire a great deal more water than the woody plants and allow the soil to deteriorate in structure and therefore in water capacity.

Some weeds and grasses, to be sure, are capable of existing where but little light reaches the soil. When they appear it is a sign to the forester that he must be careful not to thin out the crown cover any more. When the more light-needing weeds and grasses appear it is a sign that too much light reaches the ground, and that the soil is already deteriorated. If this state continues, the heavy drain which the transpiration of these weeds makes upon the soil moisture, without any appreciable conservative action by their shade, will injure the soil still further.

The overhead shade or crown cover may be imperfect because there are not enough trees on the ground to close up the interspaces with their crowns, or else because the kinds of trees which make up the forest do not yield much shade; thus it can easily be observed that a beech, a sugar maple, a hemlock, is so densely foliaged that but little light reaches the soil through its crown canopy, while an ash, an oak, a larch, when full grown, in the forest, allows a good deal of light to penetrate.

Hence, in our weeding process for the improvement of the wood crop, we must be careful not to interrupt the crown cover too much, and thereby deteriorate the soil conditions. And for the same reason, in the selection of the kinds that are to be left or to be taken out, we shall not only consider their use value but also their shading value, trying to bring about such a mixture of shady and less shady kinds as will insure a continuously satisfactory crown cover, the shade-enduring kinds to occupy the lower stratum in the crown canopy, and to be more numerous than the light-needing.

The forester, therefore, watches first the conditions of his soil cover, and his next care is for the condition of the overhead shade, the "crown cover;" for a change in the condition of the latter brings change into his soil conditions, and, inversely, from the changes in the plant cover of the soil he judges whether he may or may not change the light conditions. The changes of the soil cover teach him more often when "to let alone" than when to go on with his operations of thinning out; that is to say, he can rarely stop short of that condition which is most favorable. Hence the improvement cuttings must be made with caution and only very gradually, so that no deterioration of the soil conditions be invited. We have repeated this injunction again and again, because

all success in the management of future wood crops depends upon the care bestowed upon the maintenance of favorable soil conditions.

As the object of this weeding is not only to remove the undesirable kinds from the present crop, but to prevent as much as possible their reappearance in subsequent crops, it may be advisable to cut such kinds as sprout readily from the stump in summer time—June or July—when the stumps are likely to die without sprouting.

It may take several years' cutting to bring the composition of the main crop into such a condition as to satisfy us.

METHODS OF REPRODUCING THE WOOD CROP.

Then comes the period of utilizing the main crop. As we propose to keep the wood lot as such, and desire to reproduce a satisfactory wood crop in place of the old one, this latter must be cut always with a view to that reproduction. There are various methods pursued for this purpose in large forestry operations which are not practicable on small areas, especially when these are expected to yield only small amounts of timber, and these little by little as required. It is possible, to be sure, to cut the entire crop and replant a new one, or else to use the ax skillfully and bring about a natural reproduction in a few years; but we want in the present case to lengthen out the period during which the old crop is cut, and hence must resort to other methods. There are three methods practicable.

We may clear narrow strips or bands entirely, expecting the neighboring growth to furnish the seed for covering the strip with a new crop—"the strip method;" or we can take out single trees here and there, relying again on an after-growth from seed shed by the surrounding trees—the "selection method;" or, finally, instead of single trees, we may cut entire groups of trees here and there in the same manner, the gaps to be filled, as in the other cases, with a young crop from the seed of the surrounding trees, and this we may call the "group method."

In *the strip method*, in order to secure sufficient seeding of the cleared strip, the latter must not be so broad that the seed from the neighboring growth can not be carried over it by the wind. In order to get the best results from the carrying power of the wind (as well as to avoid windfalls when the old growth is suddenly opened on the windward side) the strips should be located on the side opposite the prevailing winds. Oaks, beech, hickory, and nut trees in general with heavy seeds will not seed over any considerable breadth of strip, while with maple and ash the breadth may be made twice as great as the height of the timber, and the mother trees with lighter seeds, like spruce and pine, or birch and elm, may be able to cover strips of a breadth of 3 or 4 and even 8 times their height. But such broad strips are hazardous, since with insufficient seed fall, or fail years in the seed, the strip may remain exposed to sun and wind for several years without a good cover and deteriorate. It is safer, therefore, to make the strips no broader than just the height of the neighboring timber, in which case not only has the seed better

chance of covering the ground, but the soil and seedlings have more protection from the mother crop. In hilly country the strips must not be made in the direction of the slope, for the water would wash out soil and seed.

Every year, then, or from time to time, a new strip is to be cleared and "regenerated." But if the first strip failed to cover itself satisfactorily, the operation is stopped, for it would be unwise to remove the seed trees further by an additional clearing. Accordingly, this method should be

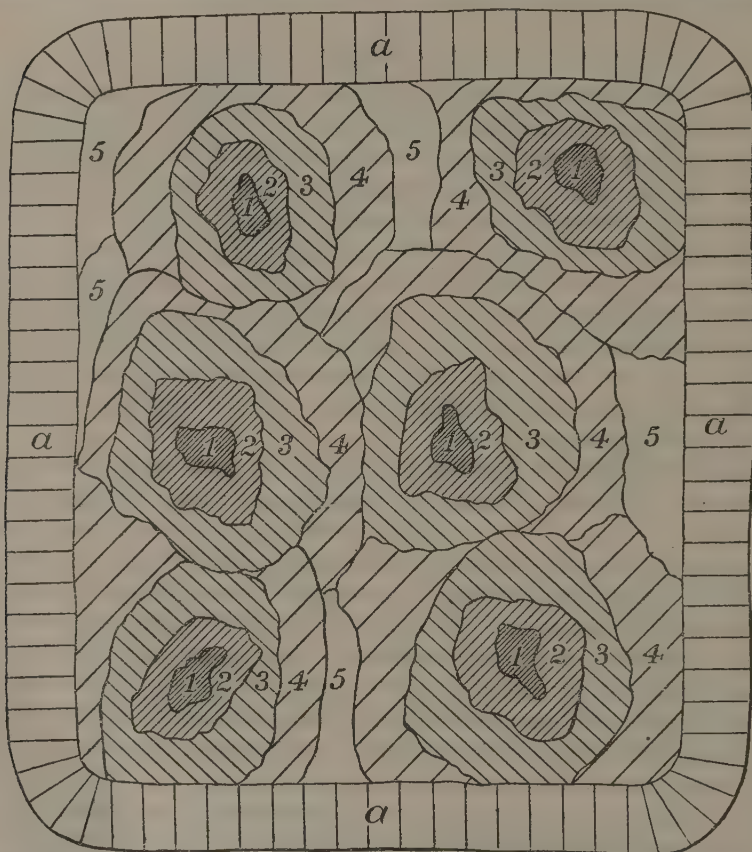

FIG. 128.—Showing plan of group system in regenerating a forest crop. 1, 2, 3, 4, successive groups of young timber, 1 being the oldest, 4 the youngest, 5 old timber; *a*, wind mantle, specially managed to secure protection.

used only where the kinds composing the mother crop are frequent and abundant seeders and give assurance of reseeding the strips quickly and successfully.

The other two methods have greater chances of success in that they preserve the soil conditions more surely, and there is more assurance of seeding from the neighboring trees on all sides.

The selection method, by which single trees are taken out all over the forest, is the same as has been practiced by the farmer and lumberman

hitherto, only they have forgotten to look after the young crop. Millions of seed may fall to the ground and germinate, but perish from the excessive shade of the mother trees. If we wish to be successful in establishing a new crop, it will be necessary to be ready with the ax all the time and give light as needed by the young crop. The openings made by taking out single trees are so small that there is great danger of the young crop being lost, or at least impeded in its development, because it is impracticable to come in time to its relief with the ax.

The best method, therefore, in all respects, is the "*group method*," which not only secures continuous soil cover, chances for full seeding, and more satisfactory light conditions, but requires less careful attention, or at least permits more freedom of movement and adaptation to local conditions (fig. 128).

It is especially adapted to mixed woods, as it permits securing for each species the most desirable light conditions by making the openings larger or smaller, according as the species we wish to favor in a particular group demand more or less shade. Further, when different species are ripe for regeneration at different times, this plan makes it possible to take them in hand as needed. Again, we can begin with one group or we can take in hand several groups simultaneously, as may be desirable and practicable.

We start our groups of new crop either where a young growth is already on the ground, enlarging around it, or where old timber has reached its highest usefulness and should be cut in order that we may not lose the larger growth which young trees would make; or else we choose a place which is but poorly stocked, where, if it is not regenerated, the soil is likely to deteriorate further. The choice is affected further by the consideration that dry situations should be taken in hand earlier than those in which the soil and site are more favorable, and that some species reach maturity and highest use value earlier than others and should therefore be reproduced earlier. In short, we begin the regeneration when and where the necessity for it exists, or where the young crop has the best chance to start most satisfactorily with the least artificial aid. Of course, advantage should be taken of the occurrence of seed years, which come at different intervals with different species.

If we begin with a group of young growth already on the ground, our plan is to remove gradually the old trees standing over them when no longer required for shade, and then to cut away the adjoining old growth and enlarge the opening in successive narrow bands around the young growth. When the first band has seeded itself satisfactorily, and the young growth has come to require more light (which may take several years), we remove another band around it, and thus the regeneration progresses. Where no young growth already exists, of course the first opening is made to afford a start, and afterwards the enlargement follows as occasion requires.

SIZE OF OPENINGS.

The size of the openings and the rapidity with which they should be enlarged vary, of course, with local conditions and the species which is to be favored, the light-needing species requiring larger openings and quicker light additions than the shade-enduring. It is difficult to give any rules, since the modifications due to local conditions are so manifold, requiring observation and judgment. Caution in not opening too much at a time and too quickly may avoid failure in securing good stands.

In general, the first openings may contain from one-fourth to one-half an acre or more, and the gradual enlarging may progress by clearing bands of a breadth not to exceed the height of the surrounding timber.

The time of the year when the cutting is to be done is naturally in winter, when the farmer has the most leisure, and when the wood seasons best after felling and is also most readily moved. Since it is expected that the seed fallen in the autumn will sprout in the spring, all wood should, of course, be removed from the seed ground.

The first opening, as well as the enlargement of the groups, should not be made at once, but by gradual thinning out, if the soil is not in good condition to receive and germinate the seed and it is impracticable to put it in such condition by artificial means—hoeing or plowing.

It is, of course, quite practicable—nay, sometimes very desirable—to prepare the soil for the reception and germination of the seed. Where undesirable undergrowth has started, it should be cut out, and where the soil is deteriorated with weed growth or compacted by the tramping of cattle, it should be hoed or otherwise scarified, so that the seed may find favorable conditions. To let pigs do the plowing and the covering of acorns is not an uncommon practice abroad.

It is also quite proper, if the reproduction from the seed of the surrounding mother trees does not progress satisfactorily, to assist, when an opportunity is afforded, by planting such desirable species as were or were not in the composition of the original crop.

It may require ten, twenty, or forty years or more to secure the reproduction of a wood lot in this way. A new growth, denser and better than the old, with timber of varying age, will be the result. The progress of the regeneration in groups is shown on the accompanying plan, the different shadings showing the successive additions of young crop, the darkest denoting the oldest parts, first regenerated. If we should make a section through any one of the groups, this, ideally represented, would be like figure 129, the old growth on the outside, the youngest new crop adjoining it, and tiers of older growths of varying height toward the center of the group.

WIND MANTLE.

On the plan there will be noted a strip specially shaded, surrounding the entire plat (fig. 128, *a*), representing a strip of timber which should surround the farmer's wood lot, and which he should keep as dense as

possible, especially favoring undergrowth. This part, if practicable, should be kept reproduced as coppice or by the method of selection, i. e., by taking out trees here and there. When gaps are made, they should be filled, if possible, by introducing shade-enduring kinds, which, like the spruces and firs and beech, retain their branches down to the foot for a long time. This mantle is intended to protect the interior against the drying influence of winds, which are bound to enter the small wood lot and deteriorate the soil. The smaller the lot, the more necessary and desirable it is to maintain such a protective cover or windbreak.

FIG. 129.—Appearance of regeneration by group method.

COPPICE.

Besides reproducing a wood crop from the seed of mother trees or by planting, there is another reproduction possible by sprouts from the stump. This, to be sure, can be done only with broad-leafed species, since conifers, with but few exceptions, do not sprout from the stump. When a wood lot is cut over and over again, the reproduction taking place by such sprouts we call coppice.

Most wooded areas in the Eastern States have been so cut that reproduction from seed could not take place, and hence we have large areas

of coppice, with very few seedling trees interspersed. As we have seen in the chapter on "How trees grow," the sprouts do not develop into as good trees as the seedlings. They grow faster, to be sure, in the beginning, but do not grow as tall and are apt to be shorter lived.

For the production of firewood, fence, and post material, coppice management may suffice, but not for dimension timber. And even to keep the coppice in good reproductive condition, care should be taken to secure a certain proportion of seedling trees, since the old stumps, after repeated cutting, fail to sprout and die out.

Soil and climate influence the success of the coppice; shallow soils produce weaker but more numerous sprouts and are more readily deteriorated by the repeated laying bare of the soil; a mild climate is most favorable to a continuance of the reproductive power of the stump.

Some species sprout more readily than others; hence the composition of the crop will change, unless attention is paid to it. In the coppice, as in any other management of a natural wood crop, a desirable composition must first be secured, which is done by timely improvement cuttings, as described in a previous section.

The best trees for coppice in the northeastern States are the chestnut, various oaks, hickory, ash, elm, maples, basswood, and black locust, which are all good sprouters.

When cutting is done for reproduction, the time and manner are the main care. The best results are probably obtained, both financially and with regard to satisfactory reproduction, when the coppice is cut between the twentieth and thirtieth years. All cutting must be done in early spring or in winter, avoiding, however, days of severe frost, which is apt to sever the bark from the trunk and to kill the cambium. Cutting in summer kills the stump, as a rule. The cut should be made slanting downward, and as smooth as possible, to prevent collection of moisture on the stump and the resulting decay, and as close as possible to the ground, where the stump is less exposed to injuries, and the new sprouts, starting close to the ground, may strike independent roots.

Fail places or gaps should be filled by planting. This can be readily done by bending to the ground some of the neighboring sprouts, when 2 to 3 years old, notching, fastening them down with a wooden hook or a stone, and covering them with soil a short distance (4 to 6 inches) from the end. The sprout will then strike root, and after a year or so may be severed from the mother stock by a sharp cut (fig. 130).

For the recuperation of the crop, it is desirable to maintain a supply of seedling trees, which may be secured either by the natural seeding of a few mother trees of the old crop which are left, or by planting. This kind of management, coppice with seedling or standard trees intermixed, if the latter are left regularly and well distributed over the wood lot, leads to a management called "standard coppice." In this it is attempted to avoid the drawbacks of the coppice, viz, failure to produce dimension material and running out of the stocks. The former

object is, however, only partially accomplished, as the trees grown without sufficient side shading are apt to produce branchy boles and hence knotty timber, besides injuring the coppice by their shade.

PLAN OF MANAGEMENT.

In order to harmonize the requirements of the wood lot from a sylvicultural point of view, and the needs of the farmer for wood supplies, the cutting must follow some systematic plan.

The improvement cuttings need not, in point of time, have been made all over the lot before beginning the cuttings for regeneration, provided they have been made in those parts which are to be regenerated. Both the cuttings may go on simultaneously, and this enables the farmer to gauge the amount of cutting to his consumption. According to the

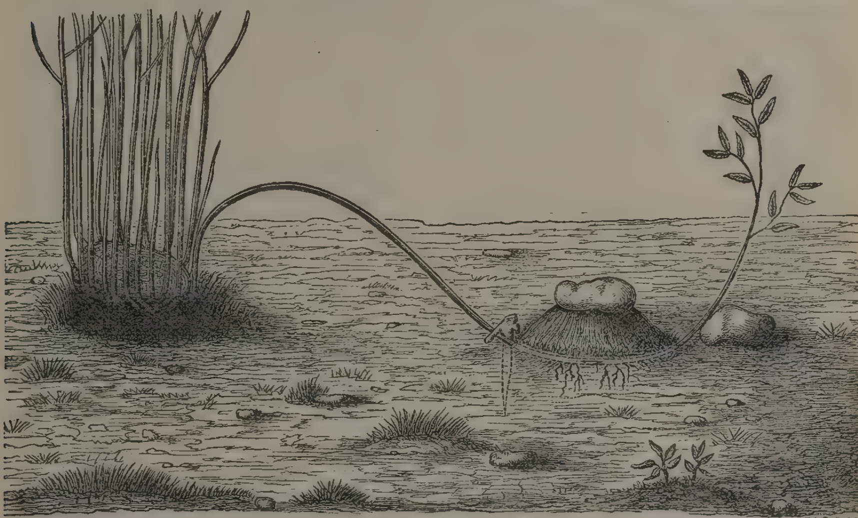

FIG. 130.—Method of layering to produce new stocks in coppice wood.

amount of wood needed, one or more groups may be started at the same time. It is, however, desirable, for the sake of renewing the crop systematically, to arrange the groups in a regular order over the lot.

4. HOW TO CULTIVATE THE WOOD CROP.

Where only firewood is desired, i. e., wood without special form, size, or quality, no attention to the crop is necessary, except to insure that it covers the ground completely. Nevertheless, even in such a crop, which is usually managed as coppice,[1] some of the operations described in this chapter may prove advantageous. Where, however, not only quantity but useful quality of the crop is also to be secured, the development of the wood crop may be advantageously influenced by controlling the supply of light available to the individual trees.

[1] See page 493 for description of coppice.

It may be proper to repeat here briefly what has been explained in previous pages regarding the influence of light on tree development.

EFFECT OF LIGHT ON WOOD PRODUCTION.

Dense shade preserves soil moisture, the most essential element for wood production; a close stand of suitable kinds of trees secures this shading and prevents the surface evaporation of soil moisture, making it available for wood production. But a close stand also cuts off side light and confines the lateral growing space, and hence prevents the development of side branches and forces the growth energy of the soil to expend itself in height growth; the crown is carried up, and long, cylindrical shafts, clear of branches, are developed; a close stand thus secures desirable form and quality. Yet, since the quality of wood production or accretion (other things being equal) is in direct proportion to the amount of foliage and the available light, and since an open position promotes the development of a larger crown and of more foliage, an open stand tends to secure a larger amount of wood accretion on each tree. On the other hand, a tree grown in the open, besides producing more branches, deposits a larger proportion of wood at the base, so that the shape of the bole becomes more conical, a form which in sawing proves unprofitable; whereas a tree grown in the dense forest both lengthens its shaft at the expense of branch growth and makes a more even deposit of wood over the whole trunk, thus attaining a more cylindrical form. While, then, the total amount of wood production per acre may be as large in a close stand of trees as in an open one (within limits), the distribution of this amount among a larger or smaller number of individual trees produces different results in the quality of the crop. And since the size of a tree or log is important in determining its usefulness and value, the sooner the individual trees reach useful size, without suffering in other points of quality, the more profitable the whole crop.

NUMBER OF TREES PER ACRE.

The care of the forester, then, should be to maintain the smallest number of individuals on the ground which will secure the greatest amount of wood growth in the most desirable form of which the soil and climate are capable, without deteriorating the soil conditions. He tries to secure the most advantageous individual development of single trees without suffering the disadvantages resulting from too open stand. The solution of this problem requires the greatest skill and judgment, and rules can hardly be formulated with precision, since for every species or combination of species and conditions these rules must be modified.

In a well-established young crop the number of seedlings per acre varies greatly, from 3,000 to 100,000, according to soil, species, and the manner in which it originated, whether planted, sown, or seeded

naturally.[1] Left to themselves, the seedlings, as they develop, begin to crowd each other. At first this crowding results only in increasing the height growth and in preventing the spread and full development of side branches; by and by the lower branches failing to receive sufficient light finally die and break off—the shaft "clears itself." Then a distinct development of definite crowns takes place, and after some years a difference of height growth in different individuals becomes marked. Not a few trees fail to reach the general upper crown surface, and, being more or less overtopped, we can readily classify them according to height and development of crown, the superior or "dominating" ones growing more and more vigorously, the inferior or "dominated" trees falling more and more behind, and finally dying for lack of light, and thus a natural reduction in numbers, or thinning, takes place. This natural thinning goes on with varying rates at different ages, continuing through the entire life of the crop, so that, while only 4,000 trees per acre may be required in the tenth year to make a dense crown cover or normally close stand, untouched by man, in the fortieth year 1,200 would suffice to make the same dense cover, in the eightieth year 350 would be a full stand, and in the one hundredth not more than 250, according to soil and species, more or less. As we can discern three stages in the development of a single tree—the juvenile, adolescent, and mature—so, in the development of a forest growth, we may distinguish three corresponding stages, namely, the "thicket" or brushwood, the "pole-wood" or sapling, and the "timber" stage. During the thicket stage, in which the trees have a bushy appearance, allowing hardly any distinction of stem and crown, the height growth is most rapid. This period may last, according to conditions and species, from 5 or 10 to 30 and even 40 years—longer on poor soils and with shade-enduring species, shorter with light-needing species on good soils—and, while it lasts, it is in the interest of the wood grower to maintain the close stand, which produces the long shaft, clear of branches, on which at a later period the wood that makes valuable, clear timber, may accumulate. Form development is now most important. The lower branches are to die and break off before they become too large. (See illustrations of the progress of "clearing," on pp. 473 and 474.) With light-needing species and with deciduous trees generally this dying off is accomplished more easily than with conifers. The spruces and even the white pine require very dense shading to "clear" the shaft. During this period it is only necessary to weed out the undesirable kinds, such as trees infested by insect and fungus, shrubs, sickly, stunted, or bushy trees which are apt to overtop and prevent the development of their better neighbors. In short, our attention is now devoted mainly to improving the composition of the crop.

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[1] If the crop does not, at 3 to 5 years of age, shade the ground well, with a complete crown cover, or canopy, it can not be said to be well established and should be filled out by planting.

WEEDING AND CLEANING THE CROP.

This weeding or cleaning is easily done with shears when the crop is from 3 to 5 years old. Later, mere cutting back of the undesirable trees with a knife or hatchet may be practiced. In well-made artificial plantations this weeding is rarely needed until about the eighth or tenth year. But in natural growths the young crop is sometimes so dense as to inordinately interfere with the development of the individual trees. The stems then remain so slender that there is danger of their being bent or broken by storm or snow when the growth is thinned out later. In such cases timely thinning is indicated to stimulate more rapid development of the rest of the crop. This can be done most cheaply by cutting swaths or lanes one yard wide and as far apart through the crop, leaving strips standing. The outer trees of the strip, at least, will then shoot ahead and become the main crop. These weeding or improvement cuttings, which must be made gradually and be repeated every two or three years, are best performed during the summer months, or in August and September, when it is easy to judge what should be taken out.

METHODS OF THINNING.

During the "thicket" stage, then, which may last from 10 to 25 and more years, the crop is gradually brought into proper composition and condition. When the "pole-wood" stage is reached, most of the saplings being now from 3 to 6 inches in diameter and from 15 to 25 feet in height, the variation in sizes and in appearance becomes more and more marked. Some of the taller trees begin to show a long, clear shaft and a definite crown. The trees can be more or less readily classified into height and size classes. The rate at which the height growth has progressed begins to fall off and diameter growth increases. Now comes the time when attention must be given to increasing this diameter growth by reducing the number of individuals and thus having all the wood which the soil can produce deposited on fewer individuals. This is done by judicious and often repeated thinning, taking out some of the trees and thereby giving more light and increasing the foliage of those remaining; and as the crowns expand, so do the trunks increase their diameter in direct proportion. These thinnings must, however, be made cautiously lest at the same time the soil is exposed too much, or the branch growth of those trees which are to become timber wood is too much stimulated. So varying are the conditions to be considered, according to soil, site, species, and development of the crop, that it is well-nigh impossible, without a long and detailed discussion, to lay down rules for the proper procedure. In addition the opinions of authorities differ largely both as to manner and degree of thinning, the old school advising moderate, and the new school severer thinnings.

For the farmer, who can give personal attention to detail and whose object is to grow a variety of sizes and kinds of wood, the following general method may perhaps be most useful:

First determine which trees are to be treated as the main crop or "final harvest" crop. For this 300 to 500 trees per acre of the best grown and most useful kinds may be selected, which should be distributed as uniformly as possible over the acre. These, then—or as many as may live till the final harvest—are destined to grow into timber and are to form the special favorites as much as possible. They may at first be marked to insure recognition; later on they will be readily distinguished by their superior development. The rest, which we will call the "subordinate" crop, is then to serve merely as filler, nurse, and soil cover.

WHAT TREES TO REMOVE.

It is now necessary, by careful observation of the surroundings of each of the "final harvest" crop trees, or "superiors," as we may call them, to determine what trees of the "subordinate" crop trees, or "inferiors," must be removed. All nurse trees that threaten to overtop the superiors must either be cut out or cut back and topped, if that is practicable, so that the crown of the superiors can develop freely. Those that are only narrowing in the superiors from the side, without preventing their free top development, need not be interfered with, especially while they are still useful in preventing the formation and spreading of side branches on the superiors. As soon as the latter have fully cleared their shafts, these crowding inferiors must be removed. Care must be taken, however, not to remove too many at a time, thus opening the crown cover too severely and thereby exposing the soil to the drying influence of the sun. Gradually, as the crowns of inferiors standing farther away begin to interfere with those of the superiors, the inferiors are removed, and thus the full effect of the light is secured in the accretion of the main harvest crop; at the same time the branch growth has been prevented and the soil has been kept shaded. Meanwhile thinnings may also be made in the subordinate crop, in order to secure also the most material from this part of the crop. This is done by cutting out all trees that threaten to be killed by their neighbors. In this way many a useful stick is saved and the dead material, only good for firewood, lessened. It is evident that trees which in the struggle for existence have fallen behind, so as to be overtopped by their neighbors, can not, either by their presence or by their removal, influence the remaining growth. They are removed only in order to utilize their wood before it decays.

It may be well to remark again that an undergrowth of woody plants interferes in no way with the development of the main crop, but, on the contrary, aids by its shade in preserving favorable moisture conditions. Its existence, however, shows in most cases that the crown cover is not

as dense as it should be, and hence that thinning is not required. Grass and weed growth, on the other hand, is emphatically disadvantageous and shows that the crown cover is dangerously open.

The answer to the three questions, When to begin the thinnings, How severely to thin, and How often to repeat the operation, must always depend upon the varying appearance of the growth and the necessities in each case. The first necessity for interference may arise with light-needing species as early as the twelfth or fifteenth year; with shade-enduring, not before the twentieth or twenty-fifth year. The necessary severity of the thinning and the repetition are somewhat interdependent. It is better to thin carefully and repeat the operation oftener than to open up so severely at once as to jeopardize the soil conditions. Especially in younger growths and on poorer soil, it is best never to open a continuous crown cover so that it could not close up again within 3 to 5 years; rather repeat the operation oftener. Later, when the trees have attained heights of 50 to 60 feet and clear boles (which may be in 40 to 50 years, according to soil and kind) the thinning may be more severe, so as to require repetition only every 6 to 10 years.

The condition of the crown cover, then, is the criterion which directs the ax. As soon as the crowns again touch or interlace, the time has arrived to thin again. In mixed growths it must not be overlooked that light-needing species must be specially protected against shadier neighbors. Shade-enduring trees, such as the spruces, beech, sugar maple, and hickories, bear overtopping for a time and will then grow vigorously when more light is given, while light-needing species, like the pines, larch, oaks, and ash, when once suppressed, may never be able to recover.

Particular attention is called to the necessity of leaving a rather denser "wind mantle" all around small groves. In this part of the grove the thinning must be less severe, unless coniferous trees on the outside can be encouraged by severe thinning to hold their branches low down, thus increasing their value as windbreaks.

The thinnings, then, while giving to the "final harvest" crop all the advantage of light for promoting its rapid development into serviceable timber size, furnish also better material from the subordinate crop. At 60 to 70 years of age the latter may have been entirely removed and only the originally selected "superiors" remain on the ground, or as many of them as have not died and been removed; 250 to 400 of these per acre will make a perfect stand of most valuable form and size, ready for the final harvest, which should be made as indicated in the preceding chapter.

BEST ROADS FOR FARMS AND FARMING DISTRICTS.

By Roy Stone,

Special Agent and Engineer, U. S. Department of Agriculture.

So few really good roads have been made in purely agricultural districts that experience avails but little toward determining what will best serve the needs and suit the means of the average farmer.

In the first place, the road that will best suit the needs of the farmer must not be too costly; in the second place, it must be of the very best kind, for the farmer should be able to do his heavy hauling over it when his fields are too wet to work and his teams are free.

The roads which have been built by counties have not always satisfied the farmers who had to use them. In some portions of Ohio we find the country people in dry weather traveling in the ditches to save the bare feet of their horses from the rough stone.

KIND OF ROAD FOR THE FARMER.

The road that would seem to fill the farmer's needs, all things considered, is a solid, well-bedded stone road, so narrow as to be only a single track, but having an earth track alongside. A fine, dry, smooth dirt track is the perfection of roads; it is easy on the horses' feet and legs, easy on vehicles, and free from noise and jar. It holds snow better than stone or gravel, and requires less snow to make sleighing; and where such a track has a stone road alongside to take the travel in wet weather it will suffer hardly any appreciable wear. The stone road, on the other hand, wears by the grinding of the wheels and the chipping of the horses' calks in dry weather more than in wet. If it can be saved this wear for an average of six months in each year, so much will be clear gain.

The questions raised regarding this method of construction are, Can the junctions of the earth and stone sections of the road be kept even, so as not to have a jog in passing from one to the other, and can the meeting and passing of loaded teams be provided for? But practical experience has already been sufficient to settle both these points. The Canandaigua (New York) roads show no sign of division between the earth and stone, and those who use them say no difficulty is found in

the passing of teams, since practically no two teams ever turn out at exactly the same spot, and no rutting of the earth road occurs. The purposes of a wide, hard road are better served by a narrow one, and all the objections to it removed, while the cost is cut down one-half, and the charges for repair nearly three-fourths.

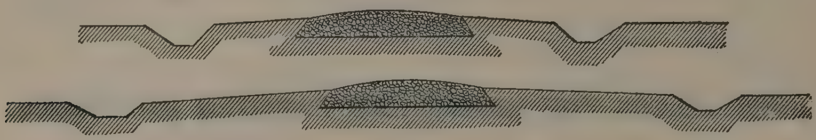

FIG. 131.—Cross sections of Canandaigua roads.

The cross sections of the Canandaigua roads shown in figure 131 give the simplest forms for narrow, hard roads; both these forms are symmetrical, having the stone road in the middle. One of them has a dirt track on each side; the other has only a shoulder of earth to keep the macadam in place. While the users of these roads are so pleased with the novelty of their hard roads that they do not seem to care for the dirt track, they will doubtless in future find their advantage in having at least one such track in all cases. One of the great highways in

FIG. 132.—Underdrain for wet places in roads.

Ohio was built in this manner thirty years ago and has given great satisfaction.

Where roads are already graded wide enough, it is better perhaps to have the three tracks, one of stone and an earth track on each side, but two will serve all purposes of use quite as well. Two tracks will require a roadbed about 21 feet wide.

In all wet soils or springy places there should be an underdrain beneath the stone track, as shown in figure 132, with side outlets at places where they are practicable. The space above the drain tile up to within 6 inches of the surface can be filled with any cheap coarse

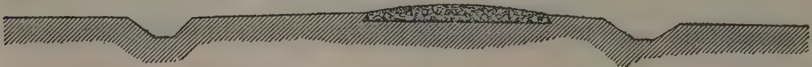

FIG. 133.—Underdrain for porous roads.

material, first covering the tile with straw to prevent the earth washing into the joints. Field stone, common gravel, sand, or burnt clay will serve for such filling. This should be well rolled and the road finished with a layer of the best broken stone or gravel obtainable, also well rolled; or, better still, with two layers of 3 inches each, rolled separately.

Where the underlying soil is naturally porous, the simple construction in figure 133 is all that is required, but the ground under the macadam should be well rolled and compacted and all soft places exca-

FIG. 134.—Drainage for macadam bed.

vated and filled with good material. If the ground is not porous, yet is not wet enough to warrant the expense of subdrainage, it is well to provide a drainage for the macadam bed, in the form shown in figure 134. All that is required for this is to give a slight outward slope to the bottom of the bed, roll the ground thoroughly, and provide an occasional drain through the earth shoulder into the ditch.

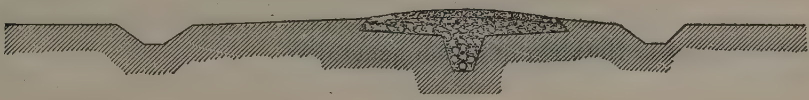

FIG. 135.—Three-track road.

The three-track road, figure 135, requires a roadbed about 27 feet wide; its construction corresponds with that of the two-track.

FARM ROADS.

Another form of narrow, hard road is one used by Judge Caton, of Chicago, on his Illinois farms. While these roads are made for farm use they would serve equally well for the lesser public roads of the neighborhood. The roadbed is made by plowing two furrows, 16 inches

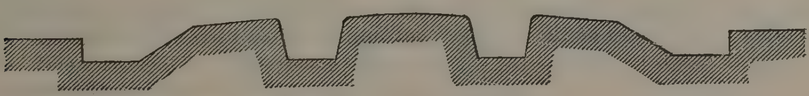

FIG. 136.—Prepared roadbed.

wide and about 12 inches deep, under what are to be the wheel tracks, turning the earth inward, and two more for ditches, also turned inward, which results in a slight raising of the bed; the inner furrows are then filled with field stones or coarse gravel and a light coating of fine gravel spread over the whole.

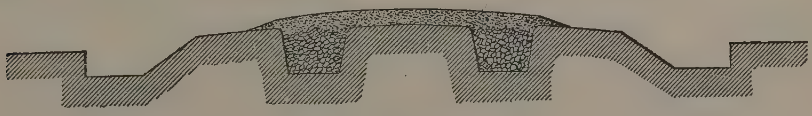

FIG. 137.—Finished road.

Figures 136 and 137, respectively, show the roadbed prepared and the finished road. This plan gives a very solid bed of material under the wheels and a sufficiency elsewhere, and if occasional side outlets

are provided the furrows are quite efficient as blind drains. Occasional passing places would need to be provided on public roads for the meeting of loaded wagons; elsewhere a width of 11 feet between the ditches would be sufficient for ordinary light travel. Such a road would use the minimum of material with the maximum of efficiency, and, having a great depth of stone just where it is needed, should bear the heaviest loads without injury, and require only an occasional resurfacing to last indefinitely. The amount of material required is less than 800 cubic yards per mile.

MAINTENANCE OF ROADS.

Regarding the maintenance of roads, what Mr. Charles E. Ashburner, jr., C. E., who has had a wide experience in such work, says of the macadam road applies with equal force to any, even the simplest of roads, and his observations are reproduced here for the benefit of those who utilize the suggestions above offered, as well as of all who are interested in the road question generally:

> The old saying, "A stitch in time saves nine," never applied more appropriately to anything than it does to the maintenance of a macadam road. Inspect your roads constantly and carefully; never allow the smallest hole to remain, but use the pick to loosen the surface as one forms and then carefully fill with chips one-half inch in diameter, or even smaller, of the same material of which the road is built, and roll. In filling be careful not to change a hole into a hillock, which would eventually cause two holes, one on each side. Equal attention should be paid to maintaining thorough drainage, so that the water will run off without saturating the edges of the roads. When the road surface at last becomes worn out, pick it thoroughly (picking by the steam roller is by far the most economical), then apply stone, and proceed as in the original construction.
>
> Roads now in my charge, built four years ago of Virginia gray granite (rejecting such as contained much mica), were only 7 inches thick. They have been constantly under heavy traffic of the worst kind, namely, country teams, which drive one behind the other in the center of the road, yet not one cent has been spent in repair, and they are as free from holes as the day they were constructed. They are worn, however, as the fine granite dust taken from the gutters will prove; but the wear has been denudation simply, owing to the fact that they were constructed upon a roadbed of uniform hardness and smoothness, and all material used was uniformly tough.

STATE HIGHWAYS IN MASSACHUSETTS.

By George A. Perkins,
Chairman Massachusetts State Highway Commission.

FIRST EFFORTS FOR IMPROVED ROADS.

Road improvement in this country is now an important factor in State as well as in municipal elections. It is incorporated into party platforms, and candidates must now declare how they stand upon this issue. This has been brought about by constant agitation on the part of those who have made a study of the question from an economic standpoint, and who have realized the immense loss resulting from the bad condition of the ways.

In Massachusetts the question on a large scale was first brought before the legislature in 1887. The people had not been made to realize the great importance of a better and more complete system of highways, so that at first the matter was not given that serious consideration it deserved. It was conceded that the roads were not of the best, but it was claimed that the cost necessary to improve them would be too great for the smaller towns to bear. It was argued before the committee that much money was uselessly applied and wasted, and that there was an entire absence of systematic methods employed. It was shown that many towns were obliged to maintain long stretches of highways of little importance to them, but used as ways of communication between large centers. It was maintained that manufacturers, teamsters, and farmers would be greatly benefited by the construction of a general system of roads, as the cost of transportation would be greatly reduced.

The subject was annually brought before the legislature, each successive year finding a larger number of advocates. In 1892 the demand for action was so great that the legislature gave it particular attention, and its committees gave a number of public hearings which were largely attended by people from every section of the State, all agreeing that the State should lend its aid and assistance toward the construction and maintenance of certain highways. The legislature fully appreciated the force of the arguments and, realizing the great scope of the subject, enacted a law providing for the appointment of a commission of three to inquire into the entire subject and report to the legislature of 1893, and granted a liberal appropriation for the purpose.

The commission thus created immediately commenced work, and at the outset could obtain but little data from any published reports as to methods and cost of construction and maintenance of roads. It at once entered upon a comprehensive plan to obtain the desired information by public hearings, communications with the different town officials, and personal investigation by traveling over hundreds of miles of country roads. In its report made to the legislature in 1893 the commission showed the importance and necessity of legislation providing for a more uniform system of road construction and maintenance under scientific supervision. From the many public hearings given by the commission and the replies to interrogatories sent to public officials, it became evident to the commission that the existing system was defective; that the ways were in a generally bad condition, and that the towns were unable to cope with the problem; that there was need for the State to undertake the construction and maintenance of a comprehensive system of State highways. It should be stated in this connection that outside of the cities there are a little more than 20,000 miles of roads in Massachusetts. It is estimated that from 10 to 15 per cent of this number are roads directly connecting the towns and large centers and such as might reasonably be asked to be made State highways. Fully 50 per cent of the annual appropriation for highways is expended for the maintenance of these intertown roads. By relieving the towns of the burden of maintaining such roads, it can readily be seen that they can use their appropriation for the improvement of their own ways.

SOME PROVISIONS OF THE ROAD LAW.

After careful consideration of the commission's report the legislature of 1893 enacted a statute which, with the amendment made by the legislature of 1894, is the law of Massachusetts to-day. It provides for the appointment of three competent persons to serve as the Massachusetts highway commission. Their terms of office shall be so arranged and designated at the time of their appointment that the term of one member shall expire in three years, one in two years, and one in one year. The full term of office thereafter shall be for three years.

The duty and power of the commission are defined, but among those of importance and value may be mentioned the following:

They may be consulted at all reasonable times, without charge, by officers of counties, cities, or towns having the care of and authority over public roads, and shall without charge advise them relative to the construction, repair, alteration or maintenance of the same; but advice given by them to any such officers shall not impair the legal duties and obligations of any city or town. They shall each year hold at least one public meeting in each county for the open discussion of questions relating to the public roads, due notice of which shall be given in the press or otherwise. They shall each year make a report to the legislature.

County commissioners and city and town officers having the care of and authority over public roads and bridges throughout the Commonwealth shall, on request, fur-

nish the commissioners any information required by them concerning the roads and bridges within their jurisdiction.

The law also contemplates the building of State highways and provides that—

Whenever the county commissioners of a county, or the mayor and aldermen of a city, or the selectmen of a town, adjudge that the public necessity and convenience require that the Commonwealth take charge of a new or existing road as a highway, in whole or in part in that county, city, or town, they may apply by a petition in writing to the Massachusetts highway commission, stating the road they recommend, together with a plan and profile of the same. Said highway commission shall consider such petition and determine what the public necessity and convenience require in the premises, and, if they decide that the highway should be laid out or be taken charge of by the Commonwealth, shall file a plan thereof in the office of the county commissioners of the county in which the petitioners reside, with the petition therefor and a certificate that they have laid out and taken charge of said highway in accordance with said plans, and shall file a copy of the plan and location of the portion lying in each city or town with the clerk of said city or town; and said highway shall, after the filing of said plans, be laid out as a highway and shall be constructed and kept in good repair and condition as a highway by the said commission, at the expense of the Commonwealth, and shall be known as a State road, and thereafter be maintained by the Commonwealth, under the supervision of said commission. And all openings and placing of structures in any such road shall be done in accordance with a permit from said commission. Said commission shall, when about to construct any highway, give to each city and town in which said highway lies a certified copy of the plans and specifications for said highway, with a notice that said commission is ready for the construction of said road. Such city or town shall have the right, without advertisement, to contract with said commission for the construction of so much of such highway as lies within its limits, in accordance with the plans and specifications, and under the supervision and subject to its approval, at a price to be agreed upon by said commission and said city or town. If said city or town shall not elect to so contract within thirty days, said commission shall advertise in two or more papers published in the county where the road or a portion of it is situated, and in three or more daily papers published in Boston, for bids for the construction of said highway under their supervision and subject to their approval, in accordance with plans and specifications to be furnished by said commission. Such advertisement shall state the time and place for opening the proposals in answer to said advertisements, and reserve the right to reject any and all proposals. All such proposals shall be sealed and shall be kept by the board, and shall be open to public inspection after said proposals have been accepted or rejected. Said commission may reject any or all bids, or if a bid is satisfactory they shall, with the approval of the governor and council, make a contract in writing on behalf of the Commonwealth for said construction, and shall require of the contractor a bond for at least 25 per cent of the contract price to indemnify any city or town in which such highway lies against damage while such road is being constructed; and the Commonwealth shall not be liable for any damage occasioned thereby. All construction of State roads shall be fairly apportioned by said commission among the different counties, and not more than 10 miles of State road shall be constructed in any one county in any one year, on petition as aforesaid, without the previous approval thereof in writing by the governor and council.

For the maintenance of State highways, said commission shall contract with the city or town in which such State highway lies, or a person, firm, or corporation, for the keeping in repair and maintaining of such highway, in accordance with the rules and regulations of said commission, and subject to their supervision and approval, and such contracts may be made without previous advertisement.

Upon the completion of the road one-quarter of the money expended is to be repaid by the county in which the way petitioned for lies, so that in the first instance the State pays for the entire expense, and collects of the county 25 per cent of the cost. In this way the towns and cities do not pay anything except the cost for the original survey and the plan and profile which must accompany the petition.

Said commission shall keep all State roads reasonably clear of brush, and shall cause suitable shade trees to be set out along said highways when feasible, and shall renew the same when necessary, and may also establish and maintain watering troughs at suitable places along said highways.

No length of possession or occupancy of land within the limit of any State highway, by an owner or occupier of adjoining land, shall create a right to such land in any adjoining owner or occupant or a person claiming under him, and any fences, buildings, sheds, or other obstructions encroaching upon such State highway shall, upon written notice by said commission, at once be removed by the owner or occupier of adjoining land, and if not so removed said commission may cause the same to be done and may remove the same upon the adjoining land of such owner or occupier.

Cities and towns shall have police jurisdiction over all State highways, and they shall at once notify in writing the State commission or its employees of any defect or want of repair in such highways. No State highway shall be dug up for the laying or placing of pipes, sewers, posts, wires, railways, or other purposes, and no trees shall be planted or removed, or obstruction placed thereon, except by the written consent of the superintendent of streets or road commissioners of a city or town, approved by the highway commission, and then only in accordance with the rules and regulations of said commission.

Said commission shall give suitable names to the State highways, and they shall have the right to change the name of any road that shall have become a part of a State highway. They shall cause to be erected at convenient points along State highways suitable guideposts.

It will be seen that the commission can not lay out State highways unless petitioned for. The amended statute took effect June 20, 1894, and $300,000 were appropriated.

The commission notified all county, city, and town authorities that, owing to the lateness of the season, action could be expected this year only on such petitions as should be received by the 1st day of August. So great was the interest that eighty-five petitions were received up to that date.

THE APPORTIONMENT OF ROADS.

The statute requires that the commission shall fairly apportion all construction of State roads among the fourteen counties. The commission apportioned the appropriation so that each county should receive nearly an equal share. It was thought wise to distribute the work so that sections could be constructed in as many places as possible, in order that the people could see what they might expect to be the policy and methods employed by the State, and that such roads would be object lessons. Under the law the municipalities in which a section of road to be constructed lies have the right, without previous advertisement and without bond, to contract directly with the commission for the building of the same. The reasons for this are that the money expended shall go directly among the townspeople, and that the officials and work-

men may have experience in such work. It also creates an interest among the people for better and more systematic work and method on local roads.

Of the eighty-five petitions the commission has acted favorably upon thirty-seven, and have contracted for that number of pieces averaging 1 mile each. These pieces in each case form a link in a through road, and in all probability will be extended. In this way it will take but a few years to complete a system of State roads. It can fairly be assumed that every town in the State will petition, and in a few years a State road will have been completed or commenced in every town. It is the aim of the commission that State highways shall be intertown roads leading to the large centers.

MISCELLANEOUS PROVISIONS OF THE LAW.

The commission furnishes blank petitions, together with all necessary information. The law requires that each petition shall be accompanied by a plan and profile, the expense of which shall be borne by the petitioners. The commission requires that all plans and profiles shall be of a uniform scale, 40 feet to the inch horizontal, and 8 feet to the inch perpendicular, samples of which and all necessary instructions are given. The State then causes cross sections of the road to be made, thus enabling a thorough study of the grades.

Although the selectmen of a town, or the mayor and aldermen of a city, can, under the statute, petition for a State road, it requires the vote of a town meeting or the city council to authorize the selectmen or mayor to contract, so that in every case where the towns or cities have contracted authority has been voted the officials. This shows that the people are in sympathy with the work.

As might be expected, the town officials at first were somewhat fearful of the risk to be assumed in entering upon such a contract, as, from lack of experience and knowledge, they might not be able to comply with the terms of the contract, as well as the liability of causing a loss to the town. But after thorough explanation, and their implicit confidence in the commission, and the fact that a resident engineer representing the State was to be always on the ground to direct and explain, these thirty-seven municipalities have contracted and entered upon the work with excellent results.

The contracts are based on the unit plan, i. e., so much per ton for stone, so much per cubic yard for earth and rock excavation and for surface grading, so much per linear foot for drains, fencing, and pipe, so much per cubic yard for rubble masonry, so much per square yard for telford, etc.

From the fact that the work was begun so late in the season only five sections have been completed, the remainder being in various stages of construction, and will be completed in the spring.

All work is done according to specifications and plans furnished by the commission, the engineer in chief having charge of all the work. In each case a resident engineer or inspector is provided, who is constantly on hand to direct the work. He makes daily and weekly returns of all work done and all material used. The town has full charge of the labor and teams, and all contracts for the same are made in the name of the town. In this way the work is progressing admirably, and the road officials of the town are being taught how to build roads in a scientific manner. The towns are paid for all work and materials used up to the 15th of each month.

METHODS OF ROAD CONSTRUCTION.

With one exception, broken stone has been used on all the roads. Each road is carefully examined with reference to its natural soil—whether clay, loam, sand, or gravel. Where the soil is clayey or heavy the commission has used telford. The method of constructing this telford is to first shape the subgrade to nearly correspond to the surface of the proposed finished roadway, and to roll this either with a steam or horse roller until it ceases to yield beneath the roller; to put in a drain on both sides if necessary, connecting the drain with some culvert, water course, or main drain. The drain is made by first excavating a trench to the depth of 2½ feet below the center of this subgrade, the bottom of the trench being about 1 foot in width and the top from 14 to 16 inches wide. From 2 to 3 inches of gravel or broken stone are placed in the bottom of the trench, and on this is laid a 5 or 6 inch vitrified clay pipe with open bell joints; then on this pipe gravel from one-fourth to three-eighths of an inch in size, or broken stone, is filled to the depth of about a foot; over this is filled coarser gravel or broken stone; the road surface is then covered with about 4 inches of gravel, and on this the telford is carefully laid by hand to the depth of about 8 inches, covering as far as possible the whole surface of the ground, the spaces being filled in with wedge-shaped stones, driven downward, the whole making a solid pavement. This telford foundation is then rolled with a steam roller until it ceases to settle; upon this is placed broken stone from 1¼ to 2½ inches in size and thoroughly rolled with a steam roller so that when compressed it will be 4 inches thick. On top of this is placed another layer of stone ranging from one-half to 1¼ inches in size, which is thoroughly rolled by a steam roller to a thickness of 2 inches. No water is used upon these two courses. On this last layer of stone, from one-half inch to an inch of the finer stone and dust from the crusher is spread. This is wet and rolled, and constitutes the binder.

The method and process of building the macadamized roads are the same as employed on the telford foundation. The commission has found that upon loose, sandy soils much stone is wasted by being driven down

into the sand; in such cases gravel, when accessible, has been placed upon the sand to a depth of 3 or 4 inches, and on this is laid the stone. By so doing the cost of the work is greatly reduced. In one instance on Marthas Vineyard, where the sand is very loose, cheap cotton cloth has been spread, upon this the stone is laid, and it is found that the sand does not work up through the stone, and much less stone is required. Layers of tarred paper were tried, but without success, as the stones were pressed through the same.

Outside of the villages the width of the hardened way is made 15 feet, with from 2½ to 3 feet of gravel on either side. The crown on substantially level roads is made one-half inch to the foot, but on grades it is made greater. The thickness of the broken stone is in most cases 6 inches in the middle and 4 inches on the sides. In all cases a steam roller is required. On grades where considerable surface water is likely to flow, cobblestone gutters are laid on the sides. The commission has not established any fixed grades, but so far the maximum has been 5 feet in the hundred.

In some of the roads petitioned for there are street railway tracks. In each instance the commission, before it would lay out a road as a State highway, has insisted that the municipal authorities cause the tracks to be located according to the plans of the commission.

Whenever the lines of the road as proposed by the commission have interfered with or cut off adjoining land, the towns have procured releases signed by the owners, relieving the State of any claim for land or grade damage.

At all angles in the road are placed stone monuments 6 feet long, 6 inches square on top, and dressed 12 inches from the top. On one side is cut the letters "M. H. B.," standing for "Massachusetts Highway Bound." The monuments are set 5 feet under ground.

PROPERTY RIGHTS, ETC.

When the road is completed and accepted, it is a State highway, and the State assumes the maintenance of it ever after. This is one of the greatest advantages gained to the towns, as by this relief their annual appropriation can be used for permanent improvements upon other roads. One of the results of the work by the commission is that towns are looking more to permanent work, and in some cases it has been voted in town meeting that a portion of the appropriation shall be set aside for such purpose.

At the beginning of the work by the State there were but few towns owning stone crushers and steam rollers. There were several large crushing plants in the State owned by private parties. Stone could be obtained from these and delivered on cars to points on railroads at an average price of $1.40 per ton. This was for stone delivered in proper sizes. But when the road to be constructed was a considerable distance from the cars, the cost of hauling brought the price so high that

it became necessary to devise some other means. Therefore arrangements have been made with parties owning crushing plants to set up a crusher, elevator, screens, and bins, and break the stone at from 30 to 40 cents per ton. The agents of the several crusher machines have entered into this, so that no difficulty is now had. In many instances the town has purchased a plant and breaks the stone. The town delivers the stone in sizes suitable for the crusher.

When a town does not own a steam roller, arrangements have been made with private parties and agents to let one to the town, the town paying for the use either by the day or per ton of stone rolled. As in case of stone crushers, many towns are buying rollers.

The commission, as called upon by the law, has given a series of hearings in the counties. These have been largely attended by people coming to seek information as to road building and maintenance. There has been great interest shown in the work of the commission and enthusiasm expressed for the continuation of the State roads.

Surveys are being made by many towns, and by spring no doubt many more petitions will be received. It is believed that a substantial sum will be appropriated for 1895, and the work begun continued.

IMPROVEMENT OF PUBLIC ROADS IN NORTH CAROLINA.

By Prof. J. A. Holmes,

State Geologist and Secretary of the North Carolina Road Improvement Association.

HISTORICAL SKETCH.

Early in the present century the State of North Carolina devoted a considerable share of attention to the subject of internal improvements, first with regard to increasing the facilities for navigation on all of the principal rivers, and then the construction of public roads from the head of navigation on each important river into the interior of the State. In 1819, and at intervals for more than a quarter of a century thereafter, the State board of internal improvements, as authorized by the general assembly, cooperated with the local authorities, on a small scale, in having roads surveyed and constructed through the more sparsely settled counties in the interior and western portions of the State.

In 1823 the engineer of the board, Hamilton Fulton, recommended the adoption by the State of the following general system: In building public roads, the roads were to be divided into three general classes: (1) A few leading roads, to be designated State roads; (2) those of lesser importance, to be known as county roads; and (3) private roads, or those of only local importance. The roads of the first class were to be constructed from a fund of which the State should contribute one-half the expense, and the counties through which the roads pass contributing their respective halves of the expense; the roads, once constructed, were to be kept in repair by the several counties traversed by them. The roads of the second class were to be both made and kept in repair by the counties, while those of the third class were to be made and kept in repair by the private individuals who were more specially benefited by the same or through whose lands the roads passed. Unfortunately, however, this plan was never adopted by the State, although in a number of cases the State did cooperate in the construction of public roads, and in 1850 to 1860 it cooperated in the construction of several plank roads in the middle and eastern counties.

It was about this time that the interest in railroad construction greatly increased in North Carolina, and for several decades thereafter the plans for public improvements turned in this and other directions, to the complete neglect of the public roads, and there was a growing belief among the people that the railroads, in a large measure, did away with the need for other public highways.

The modern movement for better public roads in North Carolina may be said to have begun in 1879 with the passage by the general assembly of the Mecklenburg road law. This was intended as a general or State law, but at the time was applied only in Mecklenburg County. It provided for the working of public roads partly by taxation and partly by the old labor system; the tax revenue to range from 7 to 20 cents on the $100 worth of property (at the discretion of the township authorities), and a labor assessment of four days on all ablebodied citizens between the ages of 18 and 45 living along these roads. The general management of the work was placed in the hands of the township authorities.

As illustrating the condition of public opinion on the subject at this time, it may be said that immediately after the enactment of this law the opposition to it in Mecklenburg, one of the most wealthy and progressive counties of the State, was so pronounced, and the demand for the repeal of the law so general, that it was repealed by the general assembly in 1881. This dissatisfaction was doubtless due in part to the fact that the work done was not altogether satisfactory, and was not carried far enough to demonstrate the benefit it would ultimately be to the public; but it was probably due still more largely to the general opposition in the State to any form of taxation for road improvement. The law had been scarcely repealed, however, before a reaction set in in its favor so strong among the intelligent people of the county that it was reenacted by the legislature of 1883. From that time to the present the extent and efficiency of the work has increased, the popularity of the new system has grown, until at the present date practically all opposition to the work has disappeared, and the only complaints now heard are to the effect that the good roads are not being extended to the outer limits of the county with sufficient rapidity.

For several years following the inauguration of the Mecklenburg road system the movement for better roads attracted but little interest in other portions of the State; and it was not until 1887 and 1889 that any decided movement was made among other counties. At this latter date new road laws were adopted by the general assembly for Alamance, Cabarrus, Forsyth, and Iredell counties, and for Raleigh Township, in Wake County. In 1891 several additional counties were added to the list, and since the session of the general assembly of 1893 a still larger number have started the improved road work, including Buncombe, Cherokee, Henderson, Macon, Mitchell, Rowan, Chatham, Edgecombe, Wayne, Lenoir, New Hanover, Onslow, and Robeson.

The laws adopted for these several counties vary considerably in their details. In nearly every case they retain in part the requirement that able-bodied citizens shall be liable for labor on the public roads for a limited number of days, and with this they combine provision for a varying rate of taxation for road purposes. In a few of the counties the money necessary for the new road work is paid out of the general county fund. In a few cases, especially in Edgecombe, the old labor

system has been abolished entirely, and the roads are being worked by taxation alone. In nearly all of these counties convict labor is employed in the road-improvement work, and in the majority of cases a limited amount of improved machinery and implements has been purchased by the counties and is being used in the work. The construction of stone roads has been undertaken in Mecklenburg, Wake, Alamance, Cabarrus, and to a lesser extent in Rowan and Durham counties. Buncombe County has just purchased a complete outfit of machinery, and is now beginning to macadamize. The work in other counties has thus far been limited to the improvement of earth roads by grading, draining, and in some cases changing the location of the old roads.

In February, 1893, a largely attended and enthusiastic road congress was held at Raleigh, during the session of the general assembly. In October following, another road meeting was held in Raleigh, during the State fair, and the North Carolina Road Improvement Association was organized. During the summer of 1894, under the auspices of this association, road conferences had been held at the State University (Chapel Hill), Raleigh, and Charlotte, and an enthusiastic road meeting was also held in Asheville in July of this year. The question of better public roads is now being agitated in every portion of the State, and it is probable that in the near future the plans for road improvement will be adopted in a number of additional counties.

ROAD IMPROVEMENT IN THE SEVERAL COUNTIES.

In *Mecklenburg County* the work has now been in progress for eleven years. During this time 32 miles of roads have been graded and drained, and 30 miles have been macadamized. The general plan adopted, and which has been adhered to, was to start at the city limits of the county seat and to grade and macadamize all of the important public roads from this point out toward the township and the county limits. These roads have a width of 40 feet for the first 2 miles from the city limits, and beyond this point a width of 36 feet. They have a maximum grade of 4 feet in 100. For cross drains sewer pipes are used in all cases where practicable, and strong wooden bridges with stone piers have been put in wherever needed.

In attaining the above grade in places where it was impracticable to change the location of the road, cuts through the hills have been made to a depth in places of from 10 to 15 feet, and fills have been made which in places have a height above the ordinary ground surface of from 10 to 20 feet for a distance of a few hundred yards to half a mile.

In macadamizing, the following general plan has been adopted: Upon the graded and settled earth surface, a macadam road, 12 feet wide and about 9 inches thick, is constructed, usually in the center, though in places on one side of the road. An excavation from 4 to 6 inches deep is made in the earth's surface, and the bottom is then carefully rolled

with a steam roller. Upon this excavated surface is placed a layer of field stone about 4 inches thick, and this is then thoroughly rolled. Upon this surface is placed a 3-inch layer of stone crushed to from 1 to 2 inches in size; and after this has been thoroughly rolled there is placed a third layer, about 2 inches thick, of finely crushed stone, including screenings, and this latter is in turn thoroughly rolled. The average cost of these roads, including the macadamizing and grading, is about $2,000 per mile. The general appearance of the roads is shown by the accompanying plate (No. VI) which gives an idea of the loads hauled over these roads; one wagon with 12 bales of cotton (6,000 pounds), and three wagons, each with a cord of wood. Much the larger part of the work for the permanent improvement of the roads in this county is done by convict labor. The average number of convicts employed is about eighty, and the average cost of this labor per convict, including their food, clothes, medical attention, and guarding, is from 20 to 22 cents per day. In charge of the work is one superintendent and one engineer (during a part of the time) and six guards. Usually the convicts have worked in one squad; at the present time they are divided into two squads. The rate of taxation in the county at the present time is 18 cents on the $100 worth of property, and the entire amount raised in this way for the support of the convict force in road-improvement work during the past year was about $18,000. In addition to this, each township levies a tax varying from 7 to 15 cents on each $100 worth of property.

The Mecklenburg law, as stated above, requires all able-bodied citizens along the public roads either to labor four days of each year on the public roads or to pay the sum of 50 cents per day in lieu thereof. This class of labor is used upon the roads independent of the convict force, and principally in the work of grading or in the general repairs of those roads or portions of them upon which the convict force is not engaged.

In *Wake County* Raleigh Township has been working its roads by taxation and labor during the past four years. It has purchased a steam-roller, road machine, crusher, spreading carts, and a complete list of smaller implements for road work. The tax rate for road purposes is now 6⅔ cents on the $100 worth of property, and the total amount thus raised for the past year was $4,600. The number of convicts employed on an average during the present season is fifty-seven, and the average cost per convict per day, including food, clothes, medical attendance, and guarding, is 20½ cents. All the county prisoners whose terms are less than ten years can be used in this work. Convicts do every kind of work except the most difficult part of the bridge construction. Twenty miles of road have been graded and 12 miles have been macadamized, the work having been divided between the principal roads in the township, starting from Raleigh. By special arrangement with the county authorities, the work has been extended for 1 to 1½ miles beyond the township boundary on three of the principal roads.

SECTION OF MACADAMIZED ROAD NEAR CAMDEN, N. C., SHOWING SIZE OF LOADS HAULED OVER IT.

The new roads have a total width of 45 feet, including ditches, and are reduced to a grade of 1 foot in 30. Of this total width 24 to 26 feet have been macadamized, leaving on one side a 12-foot earth driveway and 4 feet on each side of the road for water ways or ditches.

In putting down the macadam the foundation is carefully drained in wet places and a telford foundation is there used. In more favorable locations a sand foundation is used; where the road surface is sandy or a hardpan, the bottom layer of macadam is laid directly on that. This foundation, of whatever kind, is carefully rolled, the bottom layer of macadam (4 inches thick on the telford foundation, or 6 inches thick on the sand) of broken stone which will pass through a 4-inch ring. This layer is carefully rolled with a 15-ton steam roller, and upon it is then spread a 4-inch layer of broken stone that will pass through a 2-inch ring. This is well rolled with the steam roller, and is then covered with 1 inch to 1½ inches of crushed stone, including screenings and fragments less than 1 inch in diameter. This surface material is spread and rolled with a 2½-ton horse roller. The rock used is a biotite granite, rather soft for the best results. The cost of these roads, including both the grading and macadamizing, is reported as ranging from $1,500 to $1,700 per mile.

In *Alamance*, *Cabarrus*, and *Rowan counties* a limited amount of macadamizing has been done, and many miles of earth roads have been greatly improved by grading and draining. These counties use their convicts in working their important roads. Cabarrus employs about twenty convicts, at a cost of 42 to 45 cents per day each, while Alamance uses about the same number, at about an average cost of 22 cents per day. In the latter a county tax is levied, and able-bodied citizens are still liable under the law to work on the public roads, as heretofore. In the former, nine out of the twelve townships levy a tax of 9½ cents on $100 worth of property and 29½ cents on the poll.

Buncombe County, out of its general tax fund, maintained an average force of about sixty convicts at work on its more important public roads during 1893 and 1894, at an average cost of about 35 cents per convict per day. For general road work the old system still prevails. Many miles of earth roads have been regraded and drained, and in places relocated. A complete outfit for macadamizing work has recently been purchased, and this latter work will begin at once. As illustrating the intelligent interest in the subject of road improvements in this county, it may be stated that the county authorities recently sent a committee of six representative citizens on a tour of examination of the most important roads in New Jersey and New York, in order that such a committee might be able to examine carefully the road system adopted in those States and advise the authorities as to the best plans to be adopted for the work in their own county. At an early date it is expected that the county will vote upon a proposition to issue a quarter of a million dollars' worth of bonds to be used in the construction of stone roads.

In the other counties mentioned above no macadamizing work has as yet been undertaken, though in several of those counties the question is now being agitated, and in the near future they will doubtless begin to construct such stone roads. In all of them the earth roads have been improved, to a greater or less extent, by grading, drainage, and changes in the location of these roads. These improvements are increasing the popularity of the movement, and are thus paving the way for larger expenditures, which will be necessary in the construction of the stone roads. One of the most encouraging features of the movement has been its growth in several of the eastern counties during the past few years.

Several years ago the strongest opposition to the movement came from these eastern counties, where the surface of the country is comparatively level, and where the stone for macadamizing purposes is either exceedingly scarce or entirely absent; but during 1893 and the present year Wayne, Lenoir, Edgecombe, and New Hanover counties have adopted plans for improving their earth roads and have pushed the work forward with vigor and success, accomplishing results of decided benefit and at a small expenditure of money. This has not only brought the movement into favor in these counties, but has resulted in arousing considerable interest in the subject in a number of adjoining counties.

In *New Hanover County* a tax of 4 cents on $100 worth of property has been levied, which yields about $3,000 per annum. By the expenditure of this small sum a limited amount of grading and draining has been accomplished, and the sandy road surface has been improved by the admixture of clay, and, no doubt, in the near future these road surfaces will be still further improved by being covered either with crushed stone or with oyster shells from the adjoining sounds. A few years ago a shell road was constructed in this county for a distance of 8 miles (from Wilmington to Wrightsville), which since that time has been maintained in excellent condition by the employment of one man, who, with a cart and horse, drops small quantities of oyster shells at such points on the road as show indications of wear. This road now serves as an object lesson in showing the ease with which an excellent road can be constructed in this region and the small expenditure necessary for keeping it in repair. It extends through a level region, sandy and marshy at intervals. Ditches about 20 feet apart were dug on both sides, 2 to 4 feet deep, for the purpose of draining, and the soil removed from these ditches was thrown into the center thus elevating the roadbed. In the center of this roadbed a space 12 to 14 feet wide was covered to a depth of 6 inches with oyster shells. The travel soon ground the uppermost shells to powder, and the whole mass was packed and cemented, thus giving a hard, smooth surface. The attractiveness of the driveway has been increased by planting trees on both sides. The accompanying plate (No. VII) shows the appearance of the road and illustrates the wisdom in these sandy regions of having trees,

SECTION OF SHELL ROAD 8 MILES LONG, WILMINGTON TO WRIGHTSVILLE, NEW HANOVER COUNTY, N. C.

and especially pines, grow close by the roadside. The leaves from the trees cover the sandy surface and enable vehicles to pass over these surfaces without cutting through into the sand.

In *Edgecombe County*, as is the case also in New Hanover, no convicts are at present employed on the public roads, but it is expected that they will be so employed in both counties at an early date. A tax of 15 cents on $100 worth of property and 45 cents on the poll is assessed for road purposes, yielding a revenue which at present amounts to $7,600. Machinery is used, including a road machine, scrapers, plows, and a horse roller; ordinary labor is employed at a cost of about 65 cents per day. The policy adopted in this county has been to first improve the particularly bad places in the roads in different parts of the county, and in this way, although some slight loss of time has resulted from this moving of the outfit from place to place at short intervals, the result has been to give general satisfaction with the work in many parts of the county, because the beneficial effects of the work became apparent at once in as many places.

In *Wayne* and *Lenoir counties* the plan of improving the more important earth roads is somewhat similar to that in Edgecombe, but the tax fund is smaller in both, and convict labor is used. The trucking industry in these latter counties is one growing in importance, and this has greatly increased the demand for a road surface over which large loads can be hauled at a rapid rate without serious jolting. This demand will doubtless prove a great stimulus in the permanent improvement of public roads and will ultimately result in their being macadamized, although the material for the purpose will have to be brought from adjoining counties. At Newbern, in Craven County, so great has been the demand for better roads that recently a considerable sum was subscribed by private individuals for macadamizing a road leading from the town through one of the important trucking districts, and this road, in the building of which the county cooperated with private individuals, is now being constructed. A beautiful and serviceable macadam road was built a few years since from the town to the Federal cemetery by the United States Government, the stone used being a shell limestone.

In *Guilford County* the two townships which join at the county seat (Greensboro) have voted a small tax for the improvement of the earth roads, and have pushed this work slowly along during the past two years. In one a road machine has been used, and in the other the work has been done entirely with the pick and shovel. The notable feature in connection with the results in the two townships is the fact that in the township using the road machine the roads have not only been given better shape, but the wear of the roads has been more satisfactory.

In *Iredell County* for the present year a tax of 10 cents on the $100 worth of property and 16 cents on the poll has been levied, and a road fund of about $4,000 has been raised. During the latter part of the

present year about thirty convicts have been used on the roads, and they have graded about 20 miles of road—a few miles on each—starting from the county seat.

In *Forsyth County*, after improving the earth roads in the immediate vicinity of the county seat (Winston-Salem), the convicts, fifty to sixty in number, have been transferred to various parts of the county and have been employed in improving the worst places on the important public roads. The tax levy is 8 cents on $100 worth of property, and this yields a road fund of about $6,900, including $1,300 from the general tax fund.

ROAD MATERIALS.

In the central and western counties of the State there is usually an abundance of stone for use in macadamizing roads. The larger part of this stone is granitic in character, and some of this is rather soft for use in surfacing the road; but at intervals in all of these counties harder and tougher material can be found in the form of hornblende granite, diorite, trap, and other eruptive rocks, and where these occur along the lines of railroad they can be crushed and transported to the points where the macadam is needed, in many cases at a small cost. In the eastern counties good stone for macadam is scarce or entirely wanting; but in quite a number of these counties limestone or shell rock can be obtained at intervals, and the fact that they make a serviceable road has been demonstrated by the experiment at Newbern, where an excellent road to the Federal cemetery was built of shell rock from the Trent River, and on the streets of Goldsboro, in Wayne County, where a considerable amount of macadamizing was done some three years ago with shell rock from Castle Haynes, on the Atlantic Coast Line Railroad. In the latter case the shell rock was laid down in thickness only 3 to 4 inches. The surface was packed by the ordinary travel, and it has now withstood the constant wear of the vehicles on the main streets of Goldsboro during the past three years without the need of any repairs.

In the counties bordering the coast excellent roads can be built and maintained by the use of oyster shells, as has been shown in the case of the shell road between Wilmington and Wrightsville, in New Hanover County. In quite a number of counties limited amounts of gravel can be obtained for use on the roads, but this is usually quite inferior in quality to the Glacial gravel which abounds in many of the Northern States. Along many of the streams, however, where crossed by public roads, a sufficient supply of gravel and coarse sand can often be found, which will very greatly improve the surface when spread over it, and again in the eastern counties, where the sand prevails at intervals, along the roadside can frequently be found deposits of clay which, when mixed with sand, improve the road surface there considerably. In a few places gravel and sand deposits are found which have a sufficient amount of clay and oxide of iron intermixed to cement the mass into a hard surface.

APPENDIX.

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APPENDIX.

ORGANIZATION OF THE DEPARTMENT OF AGRICULTURE.

[Location, The Mall, between Twelfth and Fourteenth streets.]

SECRETARY OF AGRICULTURE, J. Sterling Morton.

The Secretary of Agriculture is charged with the supervision of all public business relating to the agricultural industry. He appoints all the officers and employees of the Department, with the exception of the Assistant Secretary and the Chief of the Weather Bureau, who are appointed by the President, and directs the management of all the divisions, offices, and bureaus embraced in the Department. He exercises advisory supervision over the agricultural experiment stations deriving support from the national Treasury, and has control of the quarantine stations for imported cattle, and of interstate quarantine rendered necessary by contagious cattle diseases.

ASSISTANT SECRETARY, Chas. W. Dabney, jr.

The Assistant Secretary performs such duties as may be prescribed by the Secretary. To his office has been assigned the control and direction of the scientific policy and operations of the following divisions and offices: The Divisions of Botany, Vegetable Physiology and Pathology, Agrostology, Pomology, Chemistry, Economic Ornithology and Mammalogy, Entomology, and Agricultural Soils; the Office of Experiment Stations, the Office of Irrigation Inquiry, and the Office of Fiber Investigations; and the Department Museum.

CHIEF CLERK, D. MacCuaig.

LIBRARIAN, W. P. Cutter.

BUREAUS AND DIVISIONS.

WEATHER BUREAU (corner Twenty-fourth and M streets NW.).—*Chief*, Mark W. Harrington; *assigned as Assistant Chief*, Maj. H. H. C. Dunwoody, U. S. A.; *Chief Clerk*, James R. Cook; *Professors of Meteorology*, Cleveland Abbe, F. H. Bigelow, Henry A. Hazen, Charles F. Marvin.

The Weather Bureau has charge of the forecasting of weather; the issue of storm warnings; the display of weather and flood signals for the benefit of agriculture, commerce, and navigation; the gauging and reporting of rivers; the maintenance and operation of seacoast telegraph lines, and the collection and transmission of marine intelligence for the benefit of commerce and navigation; the reporting of temperature and rainfall conditions for the cotton, rice, sugar, and other interests; the display of frost and cold-wave signals; the distribution of meteorological information in the interests of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties.

BUREAU OF ANIMAL INDUSTRY.—*Chief*, Dr. D. E. Salmon; *Chief Clerk*, P. L. Lyles.

The Bureau of Animal Industry makes investigations as to the existence of contagious pleuropneumonia and other dangerous communicable diseases of live stock, superintends the measures for their extirpation, makes original investigations as to the nature and prevention of such diseases, and reports on the condition and means of improving the animal industries of the country. It also has charge of the inspection of import and export animals, of the inspection of vessels for the transportation of export cattle, and of the quarantine stations for imported neat cattle; supervises the interstate movement of cattle, and inspects live stock and their products slaughtered for food consumption. The work of the Bureau is assigned to the following divisions: Division of Animal Pathology, Inspection Division, Division of Field Investigations and Miscellaneous Work, and Dairy Division; the last named division having been established while the present volume was in press.

DIVISION OF STATISTICS.—*Statistician,* Henry A. Robinson; *Assistant Statistician,* Henry Farquhar.

The Division of Statistics collects information as to the condition, prospects, and harvests of the principal crops, and of the numbers and status of farm animals, through a corps of county correspondents and the aid of a supplementary organization under the direction of State agents, and obtains similar information from European countries monthly through the deputy consul-general at London, assisted by consular, agricultural, and commercial authorities. It records, tabulates, and coordinates statistics of agricultural production, distribution, and consumption, the authorized data of governments, institutes, societies, boards of trade, and individual experts; and writes, edits, and publishes a monthly bulletin for the use of editors and writers, and for the information of producers and consumers, and for their protection against combination and extortion in the handling of the products of agriculture.

OFFICE OF EXPERIMENT STATIONS.—*Director,* A. C. True; *Assistant Director,* E. W. Allen.

The Office of Experiment Stations represents the Department in its relations to the experiment stations which are now in operation in all the States and Territories. It seeks to promote the interests of agricultural education and investigation throughout the United States. It collects and disseminates general information regarding the colleges and stations, and publishes accounts of agricultural investigations at home and abroad. It also indicates lines of inquiry, aids in the conduct of cooperative experiments, reports upon the expenditures and work of the stations, and in general furnishes them with such advice and assistance as will best promote the purposes for which they were established. It is also charged with investigations on the nutritive value and economy of human foods.

DIVISION OF CHEMISTRY.—*Chief Chemist,* Harvey W. Wiley; *First Assistant Chemist,* W. G. Brown.

The Division of Chemistry makes investigations of the methods proposed for the analyses of soils, fertilizers, and agricultural products, and such analyses as pertain in general to the interests of agriculture. It can not undertake the analyses of samples of the above articles of a miscellaneous nature, but application for such analyses should be made to the directors of the agricultural experiment stations of the different States. The division does not make assays of ores nor analyses of minerals except when related to general agricultural interests, nor analyses of water.

DIVISION OF ENTOMOLOGY.—*Entomologist,* L. O. Howard; *First Assistant Entomologist,* C. L. Marlatt.

The Division of Entomology obtains and disseminates information regarding insects injurious to vegetation; investigates insects sent to the division in order to give appropriate remedies; conducts investigations of this character in different parts of the country; and mounts and arranges specimens for illustrative and museum purposes.

DIVISION OF ORNITHOLOGY AND MAMMALOGY.—*Ornithologist,* C. Hart Merriam; *First Assistant Ornithologist,* T. S. Palmer.

The Division of Ornithology and Mammalogy studies the geographic distribution of animals and plants, and maps the natural life zones of the country; it also investigates the economic relations of birds and mammals, and recommends measures for the preservation of beneficial and destruction of injurious species.

DIVISION OF FORESTRY.—*Chief,* B. E. Fernow; *Assistant Chief,* Charles A. Keffer.

The Division of Forestry is occupied with experiments, investigations, and reports dealing with the subject of forestry, and with the dissemination of information upon forestry matters.

DIVISION OF BOTANY.—*Botanist,* Frederick V. Coville; *First Assistant Botanist,* J. N. Rose.

The Division of Botany maintains the National Herbarium, publishes information on the treatment of weeds, experiments with poisonous and medicinal plants, tests seeds with a view to their increased purity and commercial value, and investigates other questions of economic botany.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.—*Chief,* B. T. Galloway; *First Assistant,* Albert F. Woods.

The Division of Vegetable Physiology and Pathology has for its object a study of the normal and abnormal life processes of plants. It seeks by investigations in the field and experiments in the laboratory to determine the causes of disease and the best means of preventing the same. It studies plant physiology in its bearing on pathology.

DIVISION OF AGROSTOLOGY.—*Chief*, F. Lamson-Scribner; *First Assistant*, Jared G. Smith.

The Division of Agrostology is charged with the investigation of the natural history, geographical distribution, and uses of grasses and forage plants, their adaptation to special soils and climates, the introduction of promising native and foreign kinds into cultivation, and the preparation of publications and correspondence relative to these plants.

DIVISION OF POMOLOGY.—*Pomologist*, Samuel B. Heiges; *Assistant Pomologist*, W. A. Taylor.

The Division of Pomology collects and distributes information in regard to the fruit interests of the United States; investigates the habits and peculiar qualities of fruits, their adaptability to various soils and climates, and conditions of culture; and introduces new and untried fruits from foreign countries.

DIVISION OF AGRICULTURAL SOILS.—*Chief*, Milton Whitney.

The Division of Agricultural Soils has for its object the investigation of the texture and other physical properties of soils and their relation to crop production.

OFFICE OF FIBER INVESTIGATIONS.—*Special Agent in Charge*, Chas. Richards Dodge.

The Office of Fiber Investigations collects and disseminates information regarding the cultivation of textile plants, directs experiments in the culture of new and hitherto unused plants, and investigates the merits of new machines and processes for preparing them for manufacture.

OFFICE OF IRRIGATION INQUIRY.—*Chief*, Charles W. Irish.

The Office of Irrigation Inquiry collects and publishes information regarding the best modes of agriculture by irrigation.

OFFICE OF ROAD INQUIRY.—*Special Agent in Charge*, Roy Stone.

The Office of Road Inquiry collects information concerning the systems of road management throughout the United States, conducts investigations regarding the best method of road making, and prepares publications on this subject.

GARDENS AND GROUNDS.—*Horticulturist and Superintendent of Gardens and Grounds*, William Saunders.

The Superintendent of Gardens and Grounds is charged with the care and ornamentation of the park surrounding the Department buildings, and with the duties connected with the conservatories and gardens for testing and propagating economic plants.

DIVISION OF PUBLICATIONS.—*Chief*, Geo. Wm. Hill; *Assistant Chief*, Joseph A. Arnold.

The Division of Publications has entire supervision of the printing and publishing of the Department, and is especially charged with the preparation, publication, and distribution of farmers' bulletins. It also has general supervision of the work of illustrations. The division issues advance notices and a monthly list of publications, and prepares for publication any information of special interest to agriculturists.

DIVISION OF ACCOUNTS AND DISBURSING OFFICE.—*Chief*, Frank L. Evans; *Assistant Disbursing Officer* (in charge of Weather Bureau disbursements), A. Zappone; *Cashier*, Everett D. Yerby.

This office is charged with the adjustment of all claims against the Department; decides questions involving the expenditure of public funds; prepares contracts for annual supplies, leases, and agreements; issues requisitions for the purchase of supplies, requests for passenger and freight transportation, and attends to all business relating to the financial interests of the Department, including payments of every description.

SEED DIVISION.—*Chief*, M. E. Fagan.

The Seed Division collects new and valuable seeds for propagation in this country, and supplies them to Congressmen and others for distribution as required by law. *Special Agent for the Purchase of Seed*, Enos S. Harnden. This officer is charged with the purchase of seeds, bulbs, vines, cuttings, plants, etc., distributed by the Department.

DOCUMENT AND FOLDING ROOM.—*Superintendent*, Will H. Bane.

This division has charge of the receipt, care, and mailing of the Department publications.

MUSEUM.—*Curator*, James M. Watt.

ENGINEER.—*Chief*, John A. Harvey.

AGRICULTURAL INSTITUTIONS AND EXPERIMENT STATIONS.

List of institutions in the United States having courses in agriculture.

State.	Name of institution.	Locality.	President.
Alabama	Agricultural and Mechanical College	Auburn	W. L. Broun.
Arizona	University of Arizona	Tucson	T. B. Comstock.
Arkansas	Arkansas Industrial University	Fayetteville	J. L. Buchanan.
California	College of Agriculture of the University	Berkeley	M. Kellogg.
Colorado	The State Agricultural College	Fort Collins	Alston Ellis.
Connecticut	Storrs Agricultural College	Mansfield	B. F. Koons.
	Sheffield Scientific School of Yale University.	New Haven	Timothy Dwight.
Delaware	Delaware College	Newark	A. N. Raub.
	State College for Colored Students	Dover	Wesley Webb.
Florida	State Agricultural and Mech. College	Lake City	O. Clute.
	Florida State Normal School	Tallahassee	T. De S. Tucker.
Georgia	College of Agr'ture and Mechanic Arts	Athens	H. C. White.
Idaho	College of Agriculture of the University	Moscow	F. B. Gault.
Illinois	College of Agriculture of the University	Urbana	T. J. Burrill.
Indiana	School of Agriculture, Horticulture, and Veterinary Science of Purdue University.	La Fayette	J. H. Smart.
Iowa	College of Agr'ture and Mechanic Arts	Ames	W. M. Beardshear.
Kansas	Kansas State Agricultural College	Manhattan	Geo. T. Fairchild.
Kentucky	Agricultural and Mechanical College	Lexington	J. K. Patterson.
	State Normal School	Frankfort	J. H. Jackson.
Louisiana	State University and Agricultural and Mechanical College	Baton Rouge	J. W. Nicholson.
	Southern University and Agricultural and Mechanical College.	New Orleans	H. A. Hill.
Maine	The Maine State College	Orono	A. W. Harris.
Maryland	Maryland Agricultural College	College Park	R. W. Silvester.
Massachusetts	Massachusetts Agricultural College	Amherst	H. H. Goodell.
Michigan	Michigan Agricultural College	Agricultural College.	L. G. Gorton.
Minnesota	College of Agriculture of the University	Minneapolis	Cyrus Northrop.
Mississippi	Agricultural and Mechanical College	Agricultural College.	S. D. Lee.
	Alcorn Agricultural and Mech. College	Westside	T. J. Calloway.
Missouri	College of Agriculture and Mechanic Arts of the University.	Columbia	Richard H. Jesse.
Montana	College of Agr'ture and Mechanic Arts	Bozeman	James Reid.
Nebraska	Industrial College of the University	Lincoln	J. H. Canfield.
Nevada	School of Agriculture of University	Reno	J. E. Stubbs.
New Hampshire	College of Agriculture and the Mechanic Arts.	Durham	C. S. Murkland.
New Jersey	Rutgers Scientific School	New Brunswick	Austin Scott.
New Mexico	College of Agr'ture and Mechanic Arts	Mesilla Park	S. P. McCrea.
New York	Cornell University	Ithaca	J. G. Schurman.
North Carolina	College of Agriculture and Mech. Arts	Raleigh	A. Q. Holladay.
North Dakota	North Dakota Agricultural College	Fargo	J. B. Power.
Ohio	Ohio State University	Columbus	W. H. Scott.
Oklahoma	Agricultural and Mechanical College	Stillwater	E. D. Murdaugh.
Oregon	Oregon State Agricultural College	Corvallis	John M. Bloss.
Pennsylvania	Pennsylvania State College	State College	George W. Atherton.
Rhode Island	College of Agr'ture and Mechanic Arts	Kingston	J. H. Washburn.
South Carolina	Clemson Agricultural College	Clemson College	E. B. Craighead.
	College of Agriculture and Mechanics' Institute of Claflin University.	Orangeburg	L. M. Dunton.
South Dakota	South Dakota Agricultural College	Brookings	L. McLouth.
Tennessee	State Agricult. and Mech. College	Knoxville	C. W. Dabney, jr.
Texas	State Agricult. and Mechanical College	College Station	L. S. Ross.
Utah	Agricultural College of Utah	Logan	Joshua H. Paul.
Vermont	State Agricultural College of the University.	Burlington	M. H. Buckham.
Virginia	Agricultural and Mechanical College	Blacksburg	J. M. McBryde.
	Normal and Agricultural Institute	Hampton	H. B. Frissell.
Washington	Agric. College and School of Science	Pullman	E. A. Bryan.
West Virginia	West Virginia University	Morgantown	P. B. Reynolds.
	The West Virginia Colored Institute	Farm	J. H. Hill.
Wisconsin	College of Agric. of the University	Madison	C. K. Adams.
Wyoming	College of Agric. of the University	Laramie	A. A. Johnson.

The location, directors, dates of organization and reorganization, and principal lines of work of the agricultural experiment stations in the United States.

Station.	Location.	Director.	Date of organization.	Date of reorganization.[a]	Lines of work in addition to chemistry, horticulture, and field experiments.
Alabama (College)	Auburn	W. L. Broun	Feb. —, 1883	Feb. 24, 1888	Meteorology; botany; diseases of plants.
Alabama (Canebrake)	Uniontown	H. Benton	Jan. 1, 1886	Apr. 1, 1888	Diseases of animals.
Arizona	Tucson	T. B. Comstock		1889	Entomology; forestry; irrigation.
Arkansas	Fayetteville	R. L. Bennett		1887	Analyses of fertilizers and feeding stuffs; entomology; diseases of plants; diseases of animals.
California	Berkeley	E. W. Hilgard	1875	Jan. —, 1888	Meteorology; physics and chemistry of soils; composition and cultivation of grapes and orchard fruits (especially olives); composition of feeding stuffs; entomology; technology, drainage, and irrigation; reclamation of alkali lands.
Colorado	Fort Collins	Alston Ellis	1879	Feb. —, 1888	Meteorology; botany; entomology; irrigation.
Connecticut (State)	New Haven	S. W. Johnson	Oct. 1, 1875	May 18, 1887	Analysis and inspection of fertilizers; chemistry of feeding stuffs; chemistry of milk and its products; diseases of plants; pot experiments with organic nitrogen.
Connecticut (Storrs)	Storrs	W. O. Atwater		do	Chemistry of feeding stuffs and food of man; digestion experiments; dietary studies; bacteriology of milk and its products; dairying.
Delaware	Newark	A. T. Neale		Feb. 21, 1888	Diseases of plants; entomology; feeding experiments; dairying; diseases of animals.
Florida	Lake City	O. Clute		1888	
Georgia	Experiment	R. J. Redding	[b]Feb. 18, 1888	[c]July 1, 1889	Dairying.
Idaho	Moscow	C. P. Fox		Feb. 26, 1892	Botany; soils and waters; feeding experiments (pigs); drainage and irrigation.
Illinois	Urbana	T. J. Burrill		Mar. 21, 1888	Bacteriology; forestry; diseases of plants; entomology; feeding experiments; dairying.
Indiana	La Fayette	C. S. Plumb		Jan. —, 1888	Pot and field experiments; feeding experiments (cows and sheep); diseases of animals.
Iowa	Ames	James Wilson		Feb. 17, 1888	Diseases of plants; entomology; feeding experiments; dairying.
Kansas	Manhattan	G. T. Fairchild	(d)	Feb. 8, 1888	Diseases of plants; entomology; feeding experiments; diseases of animals; irrigation.
Kentucky	Lexington	M. A. Scovell	Sept. —, 1885	Apr. —, 1888	Soils; fertilizer analysis; diseases of plants; entomology; dairying.
Louisiana (Sugar)	New Orleans	W. C. Stubbs	do	May —, 1887	Soils; sugar making; drainage and irrigation.
Louisiana (State)	Baton Rouge	do	Apr. —, 1886	do	Geology; soils; diseases of plants; entomology; diseases of animals.
Louisiana (North)	Calhoun	do	Apr. —, 1887	do	Feeding experiments.
Maine	Orono	W. H. Jordan	Mar. —, 1885	Oct. 1, 1887	Diseases of plants; digestion and feeding experiments; diseases of animals; dairying.
Maryland	College Park	R. H. Miller	1888	Apr. 1, 1888	Soils; entomology; feeding experiments; drainage.
Massachusetts (State)	Amherst	C. A. Goessmann	1882		Analysis and control of fertilizers; digestion and feeding experiments.
Massachusetts (Hatch)	do	H. H. Goodell		Mar. 2, 1888	Meteorology; diseases of plants; entomology; diseases of animals.
Michigan	Agricultural College.	C. D. Smith	(e)	Feb. 6, 1888	Botany; soils; diseases of plants; entomology; feeding experiments; diseases of animals; dairying; irrigation.
Minnesota	St. Anthony Park.	W. M. Liggett		1888	Chemistry of foods; soils; weeds; entomology; feeding and breeding experiments; diseases of animals; dairying.
Mississippi	Agricultural College.	S. M. Tracy		Jan. 27, 1888	Botany; soils; entomology; digestion and feeding experiments; diseases of animals; drainage and irrigation.

[a] Date of organization or reorganization under act of Congress of Mar. 2, 1887.
[b] At Athens.
[c] At Experiment.
[d] Experiments reported by college since 1874.
[e] Experimental work carried on by college since organization, in 1855.

The location, directors, dates of organization and reorganization, and principal lines of work of the agricultural experiment stations, etc.—Continued.

Station.	Location.	Director.	Date of organization.	Date of reorganization.*a*	Lines of work in addition to chemistry, horticulture, and field experiments.
Missouri	Columbia	P. Schweitzer	Jan. —, 1883	Jan. —, 1888	Diseases of plants; entomology; feeding experiments; drainage.
Montana	Bozeman	S. M. Emery		July 1, 1893	Diseases of plants; feeding experiments; diseases of animals; irrigation.
Nebraska	Lincoln	C. L. Ingersoll	Dec. 16, 1884	Dec. 14, 1887	Botany; meteorology; forestry; feeding and breeding experiments; diseases of animals.
Nevada	Reno	J. E. Stubbs	May 1, 1888	Feb. 9, 1889	Botany; soils; entomology; irrigation.
New Hampshire	Durham	C. S. Murkland	1886	Aug. 4, 1887	Feeding experiments; diseases of animals; dairying.
New Jersey (State)	New Brunswick	E. B. Voorhees	Mar. 10, 1880	1888	Analysis and control of fertilizers; horticulture.
New Jersey (College)	...do	A. Scott		Apr. 26, 1888	Botany; diseases of plants; entomology; diseases of animals.
New Mexico	Mesilla Park	S. P. McCrea		Dec. 14, 1889	Botany; diseases of plants; entomology; feeding experiments.
New York (State)	Geneva	P. Collier	Mar. —, 1882		Meteorology; analysis and control of fertilizers; diseases of plants; feeding experiments; poultry experiments; dairying.
New York (Cornell)	Ithaca	I. P. Roberts	1879	Apr. —, 1888	Fertilizer investigations; diseases of plants; entomology; feeding experiments; poultry experiments; dairying.
North Carolina	Raleigh	H. B. Battle	Mar. 12, 1877	Mar. 7, 1887	Meteorology; analysis and control of fertilizers; seed testing; composition of feeding stuffs.
North Dakota	Fargo	J. B. Power		Mar. 9, 1890	Diseases of plants; feeding experiments.
Ohio	Wooster	C. E. Thorne	Apr. 25, 1882	Apr. 2, 1888	Soils; diseases of plants; entomology; breeding and feeding experiments.
Oklahoma	Stillwater	J. C. Neal		Dec. 25, 1890	Soils and waters; feeding experiments; entomology.
Oregon	Corvallis	J. M. Bloss		1888	Soils; diseases of plants; entomology; feeding experiments.
Pennsylvania	State College	H. P. Armsby	(*b*)	June 30, 1887	Meteorology; fertilizer analysis; feeding experiments; dairying.
Rhode Island	Kingston	C. O. Flagg		July 30, 1888	Pot experiments; diseases of plants; poultry experiments.
South Carolina	Clemson College	E. B. Craighead		Jan. —, 1888	Soils; analysis and control of fertilizers.
South Dakota	Brookings	L. McLouth		Mar. 11, 1887	Chemistry of waters; diseases of plants; dairying,
Tennessee	Knoxville	C. F. Vanderford	June 8, 1882	Aug. 4, 1887	Botany; entomology.
Texas	College Station	J. H. Connell		Jan. 25, 1888	Diseases of plants; entomology; feeding experiments; diseases of animals.
Utah	Logan	J. H. Paul		1890	Feeding experiments; diseases of animals; dairying; irrigation.
Vermont	Burlington	J. L. Hills	Nov. 24, 1886	Feb. 28, 1888	Analysis and control of fertilizers; diseases of plants; entomology; feeding experiments; diseases of animals; dairying.
Washington	Pullman	E. A. Bryan		1891	Soils; forestry; feeding experiments.
West Virginia	Morgantown	J. A. Myers		June 11, 1888	Meteorology; analysis and control of fertilizers; entomology.
Wisconsin	Madison	W. A. Henry	1883	1887	Soils; feeding experiments (pigs and sheep); diseases of animals; dairying; drainage and irrigation.
Wyoming	Laramie	A. A. Johnson		Mar. 1, 1891	Botany; waters; food analyses; irrigation.

a Date of organization or reorganization under act of Congress of Mar. 2, 1887. *b* Experiments carried on since 1859.

WEATHER CONDITIONS OF THE CROP OF 1894.

By H. H. C. DUNWOODY,

Assistant Chief of Weather Bureau, in charge of Forecast Division.

Figures 138 and 139 show for selected stations how the temperature and rainfall compared with normal conditions from week to week throughout the season. The

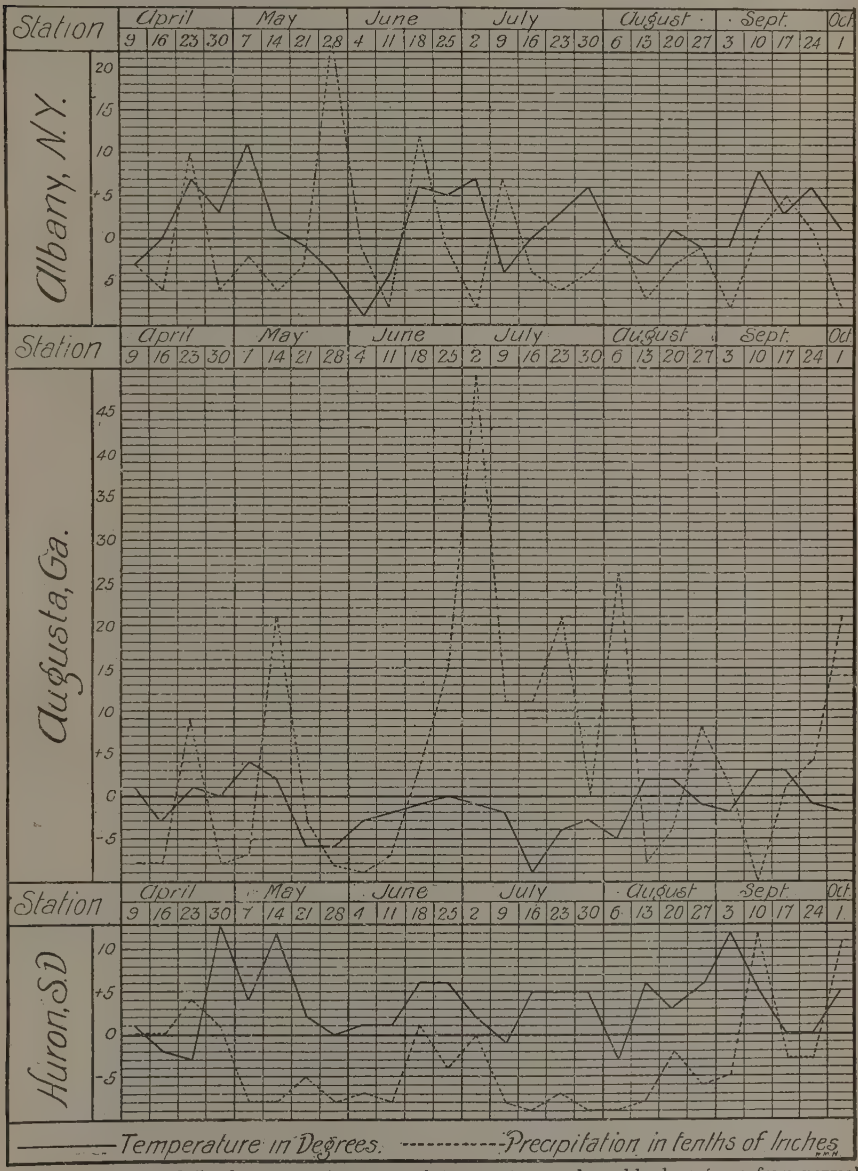

FIG. 138.—Average daily departures from normal temperature and weekly departures from normal precipitation from April 9 to October 1, 1894.

heavy horizontal line in the diagrams represents normal, the light solid line the average daily departure from normal temperature, and the dotted line the weekly departure, in inches or fractions thereof, from the normal weekly precipitation.

Similar diagrams may be constructed for any Weather Bureau station.

January was a warm month, except in California, Arizona, and portions of New Mexico, and nearly normal temperature prevailed in the Northwest. Everywhere east of the Mississippi and over the southeastern Rocky Mountain slope the month

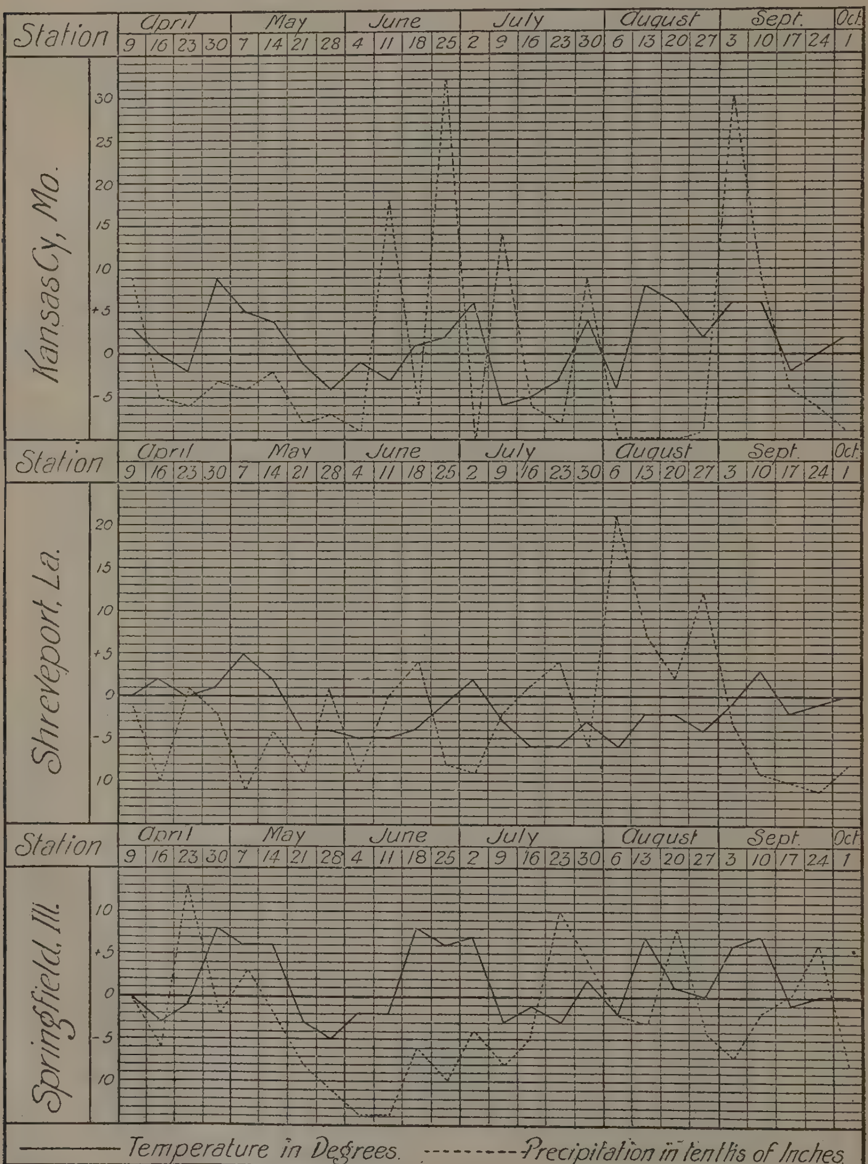

FIG. 139.—Average daily departures from normal temperature and weekly departures from normal precipitation from April 9 to October 1, 1894.

averaged decidedly warmer than usual, the temperature excess amounting to 6° per day in the central valleys and lake regions, and to 9° per day in the West Gulf States.

Except over a few areas of limited extent the precipitation of January was much below the average east of the Mississippi River, in the West Gulf States, and in

southern California; but in northern California and on the north Pacific Coast, and thence eastward to the Dakotas, the precipitation was in excess of the January average.

February averaged a cold month throughout the country, with the exception of southern Florida and along the immediate northwestern border from upper Michigan to western Montana, where it was slightly warmer than the average. The most marked deficiency in temperature occurred from the Central and Lower Mississippi Valley to the Pacific Coast, where, for the most part, the temperature averaged from 6° to 9° per day below the normal. East of the Mississippi the deficiency was less marked and only exceeded 3° per day in New England and in the States adjacent to the Lower Mississippi.

The precipitation of February was deficient in New England, southern Florida, the lake region, the Dakotas, Upper Mississippi Valley, West Gulf States, and generally throughout the plateau region, while on the north Pacific Coast, over the central Rocky Mountain slope, and from the East Gulf States northward to the lower lakes, including the Atlantic Coast States south of New England, there was more than the average precipitation, there being a decided excess over the greater part of the country east of the Mississippi and on the north Pacific Coast.

March averaged a warm month east of the Rocky Mountains, the daily average temperature excess exceeding 6° over the entire region from the Missouri Valley to the New England and Middle Atlantic Coast, and amounting to 9° per day in the lake region. In the plateau districts and on the Pacific Coast March was colder than usual.

The precipitation of March was decidedly deficient in California and to the east of the Mississippi, but in the States immediately to the westward of the Mississippi and from the upper lakes to the Pacific Coast there was a marked excess, a large portion of the area named receiving from 1 to 5 inches more than the average for March. Over much the larger portion of the Atlantic Coast States but little more than one-half of the average amount of rain fell.

The first and second decades of March were unusually warm throughout the country east of the Rocky Mountains. The effect of this warm period was to force vegetation far in advance of the season, and thereby expose it to damage from the exceptionally cold weather that prevailed during the closing days of March and the beginning of April. By the 23d of March the season was generally reported from two to three weeks earlier than usual throughout the central and northern districts from the Mississippi Valley eastward. The remarkably warm weather of the first three weeks of March was followed by a period of unusual cold, during which zero temperatures prevailed in some of the Northwestern States, and the line of freezing temperatures was carried southward to the Gulf Coast during the closing days of March. The damage resulting from the cold weather and frost was very great, and necessitated the entire replanting of many crops in the Southern States. Although the actual loss from the destruction of early vegetables, etc., was very great, it was fortunate that the cold occurred sufficiently early to enable farmers to replant the destroyed crops in ample time to secure good yields. Many tree fruits in the middle and southern portions of the country were killed, however, and the peach crop in the Middle Atlantic States was almost a total failure. The temperature extremes of the last decade of March were very unusual, both the highest and lowest thermometer readings ever recorded in March occurring over a large part of the country east of the Rocky Mountains.

The first decade of April averaged warm over the southern portions of the country and in portions of the Northwest, but it was cooler than usual over the central Rocky Mountain region, and from the Upper Mississippi Valley eastward to New England.

The last half of May and the first decade of June averaged cooler than usual over the principal agricultural districts east of the Rocky Mountains, and during this period warmer weather would have proved more beneficial to crops, but after June 10 the temperature for several weeks was above the normal and no week was sufficiently cool to prove unfavorable.

The most unfavorable features of the crop season of 1894 were the cold period covering the last week of March and beginning of April, and the protracted drought of July and August over the greater part of the country east of the Rocky Mountains, except in the Southern States.

The seasonal rainfall from March 1 to October 1 was largely deficient from the Missouri Valley eastward to the Atlantic, including the Coast States from the Carolinas northward. A marked deficiency also occurred in the Central Gulf States and California. The seasonal deficiency in rainfall exceeded 10 inches in portions of New England and the Middle Atlantic States, eastern Florida, on the Central Gulf Coast, eastern Tennessee, and from the Ohio Valley northwestward over the Central Mississippi and Missouri valleys. In but one week, from April 30 to September 10, did the rainfall for Huron, S. Dak., which is in the region of severe drought, exceed the weekly average at that station, while the temperature was above the normal

throughout almost the whole of the same period. While the actual deficiency in rainfall of 12 inches in central Iowa was equaled or exceeded in portions of Florida and eastern Tennessee, in no other section of the country east of the Rocky Mountains did the seasonal rainfall form so small a percentage of the normal amount as in Iowa and the eastern portions of Nebraska and South Dakota, where the actual rainfall was only about 50 per cent of the usual seasonal amount, although portions of New England, the Middle Atlantic States, and eastern Tennessee received less than 60 per cent of the seasonal rainfall.

The extensive and protracted drought of July and August was very injurious to crops, most seriously affecting the corn crop, the principal corn-producing States being covered by the region of severest drought.

The damaging effects of the prolonged drought were greatly intensified over South Dakota, Iowa, and portions of Kansas and Nebraska during the latter part of July by the prevalence of hot winds[1] peculiar to that region. These winds at times attained velocities approximating 40 miles per hour, and were accompanied by extremely high temperatures, ranging from 100° to 109°, with relative humidity down to 20 per cent. During the prevalence of this hot period the prospect for crops, already very unfavorable on account of prolonged drought, were greatly reduced. Much corn was completely dried up and cut for fodder. In places apples were actually burned upon the trees.

Concerning this hot period the director of the South Dakota weather service reports:

"During the early part of July showers were frequent over most of the State, except the southeast portion, but droughty conditions soon set in again, with very high day temperatures, hot winds at intervals, and much sunshine, except in the west portion. Hot winds of more than usual severity occurred on the 10th, 11th, 17th, 18th, 23d, and 26th. Probably the most permanent and damaging injury to corn was done by the extreme hot winds of the 11th and 26th. All vegetation suffered from the frequent hot winds of this month, and by the close it was evident that all crops east of the Missouri River would be a partial to total failure."

The director of the Kansas weather service states:

"The extraordinary high temperatures and hot winds characterized the week ending July 30, and all crops were seriously affected."

The director of the Iowa weather service states:

"July added to the severity of the drought by excessive temperatures and hot winds. It was altogether the driest July ever experienced in Iowa since records have been kept. The mean temperature was 76.4°—about 2.3° above normal. The culminating period of the drought was on the 25th, 26th, and 27th, during which period the wind attained maximum velocities ranging from 25 to 38 miles an hour,[1] and the maximum temperatures ranged from 100° to 109°. The average rainfall for the month was 0.63 of an inch—3.67 inches below the normal. Four stations reported only a trace, and fully three-fourths of the State received less than half an inch during the month. The mean relative humidity at the central station was only 46 per cent."

The effects of the severe drought reduced pasturage to such an extent that it was necessary to feed stock during much of the summer, and the scarcity of water proved a serious inconvenience. Short pasturage, the unfavorable prospects for corn, and the low prices being paid for wheat induced farmers to begin feeding wheat to stock. During the past summer, for the first time in the history of the country, wheat has been used extensively as feed for stock, the result of which practice has been such that it is quite likely that the custom will continue to prevail, and doubtless in future years, when the wheat crop is abundant and the yield of corn is short, the feeding of wheat to stock will form an important item in the consumption of that staple.

In the Southern States, after the cold period of the latter part of March, the general weather conditions were favorable, although there was too much rain for cotton in portions of Texas and in the eastern half of the cotton region during July, August, and September. While the severe and prolonged drought greatly reduced the corn crop in the principal corn States in the West, an unusually heavy crop of corn was made in the Southern States.

After March 1 but little rain fell in southern California, nearly the normal amount occurred over northern California, and more than the seasonal amount fell on the north Pacific Coast.

The seasonal temperature from March 1 to October 1 (215 days) averaged above the normal in all districts east of the Rocky Mountains, except along the Gulf Coast, where practically normal temperature conditions prevailed. From the Missouri Valley eastward to the Atlantic Coast the temperature for the season averaged 2° or more per day above the normal, and from the Dakotas eastward to the lower lakes and St. Lawrence Valley the daily average excess amounted to 3°, while a maximum

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[1] A special study of these hot winds has been made by Dr. I. M. Cline, Weather Bureau, and Mr. G. E. Curtis, formerly of the Weather Bureau, and the results of their investigations published.

excess of 4° per day occurred in portions of Wisconsin and the Red River Valley of the North.

The last weekly issue of the National Weather Crop Bulletin was that of October 2. During the winter the Bulletin is issued monthly only, but from December to about the close of March there is issued weekly, on Tuesday, a chart showing the depth of snow on the ground throughout the country at 8 p. m. Monday. As a covering of snow affords great protection to winter wheat, these bulletins have proved of great value to grain interests, while the reports of thickness of ice in the different sections of the country, as published in the table accompanying the snow chart, have been of much interest. The growth and extension of the State weather service that has marked the year gives assurance that more thorough work in all its lines will be accomplished during the coming year.

DIRECTIONS FOR PROCEDURE IN CASE OF APPARENT DEATH BY LIGHTNING.

* * * Electricity seldom kills outright, though the condition of suspended animation which it induces would result in death if not counteracted.

All things considered, it is rational to attempt the resuscitation of those apparently killed by electricity, and, if not too long delayed, the effort promises fair chances of success, provided proper means are instituted.

If the body has actually been submitted to a current of sufficient volume to produce destructive tissue changes, all efforts at resuscitation will of course be futile.

If, on the other hand, only respiration and the heart's action have been temporarily arrested, there is a condition of syncope simulating apparent death by drowning or from anæsthetics, and the physician knows that patients in this condition are frequently revived. Laymen will appreciate the nature of this condition if it is explained as one of exaggerated faint, and would not feel appalled upon encountering it if previously instructed how to cope with it. In an ordinary fainting spell the necessity to stimulate is universally appreciated. In syncope resulting from an electric shock stimulation is likewise indicated, but more vigorous measures are required. This is the only difference.

* * * The condition is one of exaggerated faint; prompt stimulants are necessary. *The man must be made to breathe*, if this is possible, and the efforts to induce respiration must not be suspended until breathing is fully and normally restored, or until it is absolutely certain that life is extinct. This can not be assured in less than an hour's persistent, energetic, tireless effort.

Directions for artificial respiration.—An efficacious method is that known as Howard's, which keeps the passage through the windpipe free without the aid of an assistant, and is recommended for that reason. It is as follows:

Place the subject on his back, head down and bent backward, arms folded over the head (under no conditions raise the head from the ground or floor). Place a hard roll of clothing beneath the chest, with the shoulders declining slightly over it. Open the mouth, pull the tongue forward, and with a cloth wipe out saliva or mucus. Thoroughly loosen the clothing from the neck to the waist (but do not leave the subject's body exposed, for it is essential to keep the body warm). Kneel astride the subject's hips, with your hands well opened upon his chest, thumbs pointing toward each other and resting on the lower end of the breastbone; little fingers upon the margin of the ribs and the other fingers dipping into the spaces between the ribs. Place your elbows firmly against your hips, and using your knees as a pivot, press upward and inward toward the heart and lungs, throwing your weight slowly forward for two or three seconds, until your face almost touches that of your patient, ending with a sharp push, which helps to jerk you back to your first position. At the same time relax the pressure of your hands, so that the ribs springing back to their original position will cause the air to rush into the subject's lungs. Pause for two or three seconds and then repeat these motions at the rate of about ten a minute until your patient breathes naturally, or until satisfied that life is extinct. If there is no response to your efforts, persistently and tirelessly maintained for a full hour, you may assume that life is gone.

No matter which method for respiration is used, it is important to maintain the warmth of the body by the application of hot flannels, bottles of hot water, hot bricks, warm clothing taken from bystanders, etc.

Firmly and energetically rub the limbs upward so as to force the blood to the heart and brain. If an assistant is present let him attend to this. Remember above all things that nothing must interrupt your efforts to restore breathing.

When swallowing is established, a teaspoonful of warm water, wine, diluted whisky or brandy, or warm coffee should be given. Sleep should be encouraged. In brief:

1. Make the subject breathe by artificially imitating the respiratory movements of the chest.
2. Keep the body warm.
3. Send for a physician.

WHOLESALE PRICES OF PRINCIPAL AGRICULTURAL PRODUCTS IN LEADING CITIES IN THE UNITED STATES.

CORN (PER BUSHEL).

Date.	Boston.	New York.	Atlanta.	New Orleans.	Cincinnati.	Chicago.	Minneapolis.	St. Paul.	St. Louis.	San Francisco (per cental).
1890.	*No. 2 mixed.*	*No. 2 mixed.*	*White.*	*No. 2 mixed.*	*No. 2 mixed.*	*No. 2.*	*No. 2.*	*No. 3 mixed.*	*No. 2.*	*No. 1 white.*
August	$0.57½ to $0.58	$0.52¼ to $0.52½	$0.67	$0.55	$0.49 to $0.50	$0.45¾ to $0.46	$0.45	$0.44 to $0.46	$0.43¾	$1.17½ to $1.20
September	.57½ .58	.53½ .54¼	.70	.61	.48½ .49	.45¼ .46	$0.46 to .47	.47½ .49	$0.44 to .44½	1.32½ 1.35
October	.60	.56 .56⅜	.68	.63	.53 .53½	.47¾ .48⅛	.47 .48	.47 .48	.47¾ .48	1.27½ 1.30
November	.64½	.60¾ .61⅜	.75	.65	.56½	.53⅝ .53⅞	.52 .52	.53	.51 .52	1.32½ 1.35
December	.64½	.60½ .61½	.75	$0.71 to .72	.52½	.50 .50½	.54 .55	.52 .53	.49 .49¾	1.32½
1891.								*No. 3.*		
August	.76 .77	.71¾ .72	.87	.72	.63	.60 .60¼	.57 .58	.58 .60	.53¼ .54	2.05 2.11
September	.76	.74 .75	.85	.74 .75	.64 .64½	.64¼ .65	.57 .58	.58 .59	.58¾ .59	1.85 1.87½
October	.67 .68	.61⅞ .62	.82	.69 .70	.57	.52½ .53¼	.48 .50	.48 .52	.53	1.37½ 1.40
November	.69	.69 .69½	.78	.73	.57 .58	.54 .55	.53 54	.52 .54	.48¾	1.17½ 1.20
December	.72 .73	.74 .76	.58	.58 .59	.52	.46¼ .47¼	.42½ .43½	.42 .45	.40¾ .42¼	1.40 1.45
1892.	*Steamer mixed.*							*No. 3 yellow.*		
August	.59 .59½	.59 .60	.68	.63 .64	.53 .53½	.49⅜ .49⅝	.46 .46½	.45 .47	.45½ .45¾	1.40 1.42½
September	.61	.58½	.67	.60	.50 .51	.48½ .48¾	....	.47 .48	.44 .44¼	1.37½ 1.40
October	.55½	.51⅞ .52¼	.62	.59 .60	.46½ .47	.43⅜ .43⅝	.47½	.44 .45	.40⅜ .41	1.35 1.36¼
November	.52½ .53	.50⅞ .51⅝	.60	.52 .53	.43	.41⅝ .41⅞	.39	.40 .41	.38¼	1.15 1.17½
December	.54 .55	.51½ .51⅞	.58	.51	.43	.42 .42½	.39½	.39 .40	.38½ .38⅝	1.12½ 1.15
1893.							*No. 3.*			
August	.49	.46⅛ .46¼	.57	.51	.41	.38 .38⅜	.34	.35 .36	.34¼ .34¾	1.00 1.02½
September	.50	.45 .45¼	.60	.50	.41½	.37½ .37¾	.35½	.35 .36	.34 .34½	.90 .95
October	.51	.49	.62	.53	.42½ .43	.39¾ .40⅛	....	.37 .38	.35⅜ .36	.92½ .96
November	.50	.45⅞ .46½	.60	.51 .52	.39	.38¼ .38½	.34	.37 .38	.35¾	.85 .87½
December	.46½	.44¾ .45¼	.55	.49	.40	.34⅞ .35⅛	.31¾ .32	.33 .34	.34	.90 .92½
1894.							*No. 3 yellow.*			
August	.57	.53½ .54	.68	.56 .57	.50	.46½ .46¾	.50	.45½ .46½	.44½ .45½	1.35 1.37½
September	.65½	....	.75	.70	.56	.53¾ .57¾	....	.57 .58	.53½ .54	1.25 1.27½
October	.60	.55⅛ .55½	.73	.71	.54½ .54¾	.49⅜ .49⅝	.53	.54 .54½	.49¾ .50¼	1.30 1.32½
November	.61½	.60	.57	.57	.52½	.52 .52¾	.43	.54½ .55	.48⅜ .48½	1.30 1.32½
December	.54	.58	.55	.53 .54	.46	.46¾ .47	.49	.51 .52	.45⅛ .45¼	1.27½ 1.30

WHEAT (PER BUSHEL).

1890.		No: 2 red winter.			No. 2 red winter.	No. 2 red winter.	No. 2 northern.	No. 2 northern.	No. 2 red winter.	No. 1 white.
August		$0.97⅜ to $0.97⅞			$0.93	$0.91 to $0.91¾	$0.84	$0.88 to $0.90	$.088	$1.37½
September		1.04¾ 1.06			1.00	1.00¾ 1.03	.92		$0.98½ to .99⅜	$1.37½ to 1.38¾
October		1.02⅝ 1.03½			$0.97 to .99	.96¼ .97½	.88	.90 .91	.97¾ .98¼	1.32½
November		1.09⅞ 1.10			.99	1.01⅛ 1.02	.92	.92 .93	.98¾ .98½	1.35
December		1.03⅞ 1.05⅛			.96 .97	.94	.88	.83 .85	.91⅜ .92⅛	1.32½
1891.							No. 1 hard.			
August		.99 .99¼			.87 .87½	.87½ .88	.97	.92 .93	.84⅜ .84¾	1.55 1.56¼
September		1.07¼ 1.08¾			.98½ .99	.98½ .99½	$0.93½ to .94	.88 .91	.97½ .97¾	1.70 1.71¼
October		1.03⅛ 1.04¼			.97 .97½	.95 .95¼	.93 .94	.87 .88	.93¾ .93⅞	1.67½ 1.68¾
November		1.04 1.05½			.94	.94 .94⅞	.90	.86 .87	.92⅜	1.72½ 1.73¾
December		1.05½ 1.06⅝			.96	.90½ .91¾	.87	.82 .84	.94⅛ .94¼	1.81¼ 1.82½
1892.		No. 2 red.			No. 2 red.		No. 2 northern.			No. 1 white.
August		.83⅝ .84¾			.75	.77½ .77¾	.70	.73 .75	.73¼ .73½	1.37½ 1.38¾
September		.78⅝ .79¾			.73	.73¾	.68	.68 .70	.68⅞ .69	1.28¾ 1.30
October		.79¼ .79⅛			.72½ .73	.72¾ .73¼	.64	.66 .68	.69	1.28¾ 1.30
November		.74⅝ .75⅜			.66	.70¾ .71	.64	.63 .65	.65½ .65⅞	1.27½ 1.30
December		.76⅝ .78⅛			.70	.71¼ .71¾	.62½	.62 .65	.68¾	1.26¼ 1.27½
1893.										
August		.66⅝ .68½			.52⅛ .53	.57⅝ .59½	.51	.54 .55	.54½ .54⅞	1.07½ 1.10
September		.69 .69¾			.57 .58	.62¾ .63¼	.57½	.56 .57	.59½	1.01¼ 1.02½
October		.72⅛ .72½			.64	.66 .66⅜	.59	.58 .59	.62⅜	1.04 1.05
November		.67¾ .68¼			.59½	.62½ .62⅞	.57	.58 .59	.58¼	1.02½ 1.05
December		.68⅛ .69¼			.59 .60	.63 .63½	.57½	.57 .58	.59⅜	1.02½ 1.03¾
1894.							No. 1 northern.			
August		.55¼ .56⅛			.48 .48½	.52 .53	.56½	.56½ .57	.47¾	.87½ .90
September		.57⅞ .58⅜			.51	.53 .53¾	.54½ .56¾	.52 .54½	.49¾ .50⅞	.85 .86¼
October		.56 .57½			.51⅜ .51½	.51¾ .52	.55½	.53 .54	.48½ .48¾	.77½ .78¾
November		.56½ .57			.51	.52½ .53⅛	.56¼	.54½ .55	.48½ .48⅝	.85 .86¼
December		.60⅜ .61⅛			.53	.55½ .56	.59¾	.57½ .58½	.52¼ .52⅜	.92½ .93¾

WHOLESALE PRICES OF PRINCIPAL AGRICULTURAL PRODUCTS IN LEADING CITIES IN THE UNITED STATES—Continued.

OATS (PER BUSHEL).

Date.	Boston.		New York.		Atlanta.		New Orleans.		Cincinnati.		Chicago.		Minneapolis.		St. Paul.		St. Louis.		San Francisco (per cental).	
1890.																				
	No. 2 white.		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2.*		*No. 2 mixed.*		*No. 2.*		*No. 2 mixed.*		*No. 2 white.*		*No. 2.*		*No. 1.*	
August	$0.44½ to	$0.45½		$0.40		$0.48		$0.45	$0.36¾ to	$0.39	$0.32½ to	$0.34		$0.33½	....	....		$0.33½		$1.60
September	.46	.46½	$0.40¼ to	.40½		.50	$0.47 to	.48	.38½	.39	.35	.35½	$0.35 to	.36	....	....		.33	$1.60 to	1.62½
October	.47½	.48½	.43¾	.44		.50		.47	.40½	.41	.38¼	.38¾	.36	.37	....	....		.39	1.52½	1.55
November	.54¾	.55	.49	.49⅜		.56		.55	.48¾	.49		.43½	.44	.45	....	....		.45	1.70	1.72½
December		.54½	.49	.49¼		.57		.57	.47	.48½	.43¼	.43½	.42	.43	....	....		.45	1.80	1.85½
1891.																				
August	.48	.50		.37		.50		.45	.31½	.32½	.27½	.28	.28	.30	$0.37 to	$0.38	$0.27⅛ to	.28		1.47½
September		.41	.35¼	.35¾		.46		.41	.31½	.32	.28½	.28¾	.28	.29	.27	.28		.28	1.32½	1.35
October	.37	.37½	.33	.33¼		.44		.37½	.30½	.31¼	.26¾	.27	.26	.26½	.27	.28	.27¼	.27½	1.37½	1.40
November	.39½	.40	.36¾	.37¼		.44		.38	.31¼	.31½		.30½	.30	.31	.28	.29		.28½		1.37½
December		.43½	.40½	.40¾		.44		.42	.34½	.35	.32	.32¼	.30	.31	.30½	.31		.32	1.40	1.41¼
1892.																				
August	.41	.41½	.35½	.36		.42		.40	.33	.33½	.30½	.30⅝	.31	.31½	.31½	.32		.30	1.37½	1.40
September		.42	.37½	.38		.42	.40	.41	.34	.34¼	.33⅝	.33¾		.30½	.32	.32½		.29⅝	1.32½	1.35
October	.40½	.41		.36		.42		.40	.33¼	.33½	.31	.31¼		.35¾	.32	.33	.29⅝	.29¾	1.25	1.27½
November		.41½		.35¾		.42		.38	.32	.32½		.30		.30	.29½	.30½	.28⅝	.29	1.25	1.27½
December		.43		.36½		.44		.41	.35½	.36		.31½	....	....	.31½	.32		.31	1.27½	1.30
1893.													*No. 3.*							
August		.39	.35½	.36		.40	.38	.38½	.21	.22	.23	.23⅜		.27	.29½	.30½		.22½	1.05	1.10
September	.35	.35½	.30⅛	.30¼		.38		.34	.26¼	.26½	.23¾	.24	.24	.25	.26½	.27½	.23¼	.23½	1.07½	1.10
October	.37	.37½	.34½	.34¾		.44		.36	.31	.32	.27¾	.28	.26	.27	.26½	.27½		.27¼	1.10	1.12½
November		.37½	.34½	.34¾		.42		.38		.29½		.28		.26¾	.27½	.28		.26¾	1.05	1.10
December		.38	.34⅜	.34½		.43		.38	.31½	.32		.28¾		.27	.27	.27½		.27¾	1.05	1.07½
1894.																				
August	.44	.45		.40		.47	.38	.39	.30½	.31	.28¾	.29		.30½	....	....		.28¾	1.12½	1.15
September	.38	.38½	.33¾	.34		.45	.38½	.39		.31	.29½	.30¼		.30½	.32	.32½		.30¼	1.02½	1.05
October	.37	.37½	.32½	.32¾		.44		.38		.31¼	.28¼	.28½		.30¼	.31½	.32	.28⅞	.29½	1.00	1.02½
November	.37½	.38	.32½	.32¾		.43		.38		.30½	.28¾	.29	.29¼	.29¾	.30½	.31		.29½	.95	.97½
December		.40	.33⅝	.33¾		.42	.38	.38½	.31½	.32½	.29¼	.29½	.30½	.30¾	.31	.31½		.30	.95	.97½

BARLEY (PER BUSHEL).

1890.	*No. 2 Canada.*	*No. 1 Canada.*			*No. 2, spring.*	*Choice.*	*No. 2.*	*No. 2.*	*Prime.*	*No. 1 Chevalier.*
August						$0.62 to $0.65	$0.45			$1.40 to $1.45
September						.54 .65	$0.50 to .55			1.50 1.55
October		$0.95			$0.74 to $0.75	.58 .70	.62 .65	$0.65	$0.72	1.50 1.52½
November		$0.98 to 1.00			.74 .77	.65 .72	.70 .72	.65	.75	1.52½
December	$0.90 to $0.95	.97 .99			.78 .80	.64 .73	.70 .71	.65	$0.70 to .75	1.52½
1891.	*Two-rowed State.*	*Two-rowed State.*				*Fair to choice.*				
August					.75 .78	.55 .60	.50	Nominal.		1.65
September					.70 .72	.60 .68	.55 .60			1.37½
October					.68 .70	.40 .56	.52 .56	$0.55 .57	.50 .60	1.35
November					.68 .72	.53 .60	.55 .56	.50 .55	.50	1.35
December	.70 .75	.64 .66			.68 .75	.48 .55	.50 .51	.50 .55	.55 .60	1.40 1.45
1892.									*Choice.*	
August					.64 .68	.45 .63	.40 .50			
September					.65	.48 .65	.40 .47	Nominal.		
October		.65			.65 .68	.58 .68	.38 .40	.48 .50	.65	1.15½ 1.17½
November		.63 .68			.65 .67	.48 .55	.40 .52	.48 .50	.60	1.12½ 1.15
December		.65 .68			.65 .67	.50 .58	.33 .38	.50 .55	.62 .63	1.12 1.15
1893.							*Barley.*			
August					.60 .65	.30 .35		.50 .55		
								Sample.		
September					.50 .52	.45 .52	.40	.30 .45		1.17½ 1.20
October		.55 .60			.56 .58	.46 .58	.33 .43	.35 .48	.55 .58	1.15 1.17½
November		.60 .65			.58 .60	.40 .54		.35 .48	.57	1.15 1.17½
December	.60 .65	.63 .64			.58 .60	.46 .52		.35 .48	.57	1.15 1.17½
1894.	*Six-rowed western.*	*No. 2 Milwaukee.*					*No. 4.*	*No. 2 round.*		
August					.57 .60					1.25 1.27½
September	.68 .73					.55 .57½		.45 .50	.60	1.25 1.27½
October	.68 .73	.61 .62			.62 .63	.52 .54½		.45 .50	.55 .57	1.25 1.27½
November	.65 .70	.61 .62			.60 .62	.53 .56	.48	.45 .50	.55 .56	
December	Nominal.	.63 .64			.60 .62	.52 .54½	.46	.46 .50	.55	

WHOLESALE PRICES OF PRINCIPAL AGRICULTURAL PRODUCTS IN LEADING CITIES IN THE UNITED STATES—Continued.

HAY (PER TON).

Date.	Boston.		New York.		Atlanta.		New Orleans.				Cincinnati.		Chicago.		Minneapolis.		St. Paul.		St. Louis.		San Francisco.	
	Fair to good.		*Prime timothy (per cwt.).*		*Hay. Per cwt.*		*Choice.*		*Prime.*		*No. 1 timothy.*		*No. 1 timothy.*		*Wild.*		*Wild.*		*Timothy, fancy.*		*No. 1 barley.*	
1890.																						
August	$14.00 to	$15.00	$0.85 to	$0.90		$0.90	$17.00 to	$17.50	$14.00 to	$15.00	....	....	$9.00 to	$9.50	$5.00 to	$5.50	$5.00 to	$6.50	$13.50 to	$14.00	$8.00 to	$10.00
September	13.00	14.00	.65	.75		.95		16.00	13.00	14.50	$10.00 to	$10.50	10.00	11.50	8.00	9.00	8.00	8.50		13.00	10.00	11.00
October	14.00	15.00	.55	.60		.90	16.00	17.00	14.00	15.00	9.50	10.00	9.00	10.00	8.00	8.50	8.00	8.50	13.00	13.50	10.00	12.00
November	14.00	15.00	.65	.70		.95	15.50	16.50	13.50	15.00	9.00	9.50	9.00	10.00	8.00	8.50	7.50	8.50	13.00	13.50	12.00	14.00
December	13.00	14.00	.65	.70		.90	15.50	16.50	14.00	15.00	9.00	9.50	9.50	10.00	8.00	8.50	6.00	8.25		13.00	11.00	13.00
1891.																						
August	14.00	15.00		.85		1.10		18.00	16.00	16.50	12.00	12.50	10.50	11.50		7.50	6.00	8.00		15.50	10.50	11.50
September	15.00	16.00	.85	.90		1.00	15.50	16.00	14.00	15.00	11.00	11.50	10.50	11.50	9.25	10.00	7.00	9.00		12.50	10.50	11.50
October	15.00	16.00	.80	.90		.95	15.50	16.00	13.50	15.00	9.50	10.00	10.50	11.00	7.50	8.00	6.50	8.00		12.00	10.50	11.50
November	15.00	16.00	.75	.85		.95		15.50	14.00	14.50	10.50	11.00	11.00	11.50	9.00	9.50	7.00	9.50		11.00	11.50	12.50
December	14.00	15.00	.80	.85		.90	18.00	19.00	16.50	17.50	10.50	11.00	14.00	15.00	9.00	9.50	9.00	10.50		13.00	12.00	12.50
1892.			*Per ton.*		*Per ton.*												*Timothy.*					
August	17.00	18.00		19.00		19.00	16.50	17.50	15.00	16.00	11.50	12.00	12.00	12.50		8.00	9.00	10.00		13.00	9.00	10.00
September	17.00	18.00		17.00		17.00	16.50	17.50	14.50	16.00	10.00	10.50	10.50	11.50		9.30	9.00	10.00		12.00	7.50	8.50
October	16.50	17.00	17.00	18.00		17.00	16.50	17.50	14.00	15.00	11.00	11.50	10.50	11.00		8.50	9.00	10.00		13.00		7.50
November	16.00	17.00		17.00		16.00	15.50	16.00	12.50	14.50	10.00	10.50	10.50	11.00	7.50	7.75	8.00	9.50		11.50	8.00	9.00
December	16.00	17.00		18.00		18.00	15.50	16.00	13.00	14.50	10.50	11.00	11.00	12.00	8.00	8.25	8.00	9.50		12.50	8.00	9.00
1893.																						
August	17.00	18.00		20.00		20.00	18.00	18.50	15.00	16.00		13.50	9.50	10.50		7.00	6.00	8.00		15.00	7.00	9.00
September	17.00	18.00	17.00	18.00		20.00	16.50	17.50	14.00	15.50	12.00	13.00	10.00	10.50		6.50	7.50	9.00		11.50	8.50	9.00
October	16.00	17.00	17.00	18.00		20.00	16.00	16.50	14.00	15.50		12.50	10.00	11.00	6.50	7.50	7.00	8.50		12.50	8.50	9.00
November	15.00	16.00	17.00	18.00		17.00	17.00	18.00	14.50	16.00	11.50	12.00	10.50	11.00		7.00	7.50	8.50		12.00	10.00	11.00
December	15.00	16.50		17.00		18.00	16.50	17.00	14.50	16.00	11.00	12.00	10.00	10.50	6.00	6.50	7.50	8.50		12.50	10.00	11.00
1894.																						
August	15.00	15.50		18.00		20.00		17.00	14.50	15.50	11.00	11.50	11.00	12.00	7.00	8.00	....	....		12.00	9.00	10.00
September	15.00	15.50	15.00	16.00		20.00	15.50	16.50	14.00	15.00	10.00	10.50	9.50	10.00	6.50	7.00	9.00	10.00		12.00	8.00	9.00
October	13.00	13.50		15.00	$16.00 to	20.00	16.00	16.50	14.50	15.50	9.50	10.00	10.00	10.50	7.50	8.00	9.50	10.50		11.50	9.00	10.00
November	13.00	13.50		15.00		15.00	16.00	16.50	14.50	15.50	9.00	9.50	10.00	10.50	7.00	8.00	9.50	10.50		12.00	9.00	10.00
December	13.00	13.50		15.00		15.00	16.00	17.00	14.00	15.00	10.00	10.50	10.00	11.00	8.00	8.50	10.00	11.00		12.00	9.00	10.00

COTTON (PER POUND).

Date.	Boston.	New York.	Atlanta.	New Orleans.	Cincinnati.	Chicago.	Minneapolis.	St. Paul.	St. Louis.	San Francisco (per cental).
1890.		*Middling upland.*		*Middling.*	*Middling.*				*Middling.*	
August		$\$0.12\frac{1}{4}$	$\$0.10$	$\$0.11\frac{3}{4}$	$\$0.12$				$\$0.11\frac{1}{2}$	
September		$.11$	$.10\frac{11}{20}$	$.10\frac{1}{4}$	$.11\frac{1}{2}$				$.10\frac{1}{3}$	
October		$.10\frac{3}{8}$	$\$0.08\frac{1}{2}$ to $.09$	$.10\frac{1}{16}$	$.10\frac{1}{4}$				$.10$	
November		$.09\frac{7}{8}$	$.09\frac{1}{2}$	$.09\frac{9}{16}$	$.09\frac{7}{8}$				$.09\frac{9}{16}$	
December		$.09\frac{7}{16}$	$.09\frac{1}{2}$	$.09\frac{1}{16}$	$.09\frac{3}{8}$				$.09$	
1891.										
August		$.08$	$.08$	$.07\frac{3}{4}$	$.08\frac{1}{4}$				$.07\frac{15}{16}$	
September		$.08\frac{7}{16}$	$.08\frac{1}{4}$	$.08$	$.08\frac{1}{4}$				$.08$	
October		$.08\frac{11}{16}$	$.08\frac{1}{2}$	$.08\frac{3}{8}$	$.08\frac{3}{4}$				$.08\frac{7}{16}$	
November		$.08\frac{5}{16}$	$.07\frac{1}{2}$	$.07\frac{7}{8}$	$.08\frac{1}{4}$				$.08$	
December		$.08\frac{1}{16}$	$.07\frac{1}{8}$	$.07\frac{1}{2}$	$.07\frac{7}{8}$				$.07\frac{9}{16}$	
1892.										
August		$.07\frac{1}{2}$	$.06\frac{7}{8}$	$.07\frac{3}{16}$	$.07\frac{5}{8}$				$.07\frac{3}{16}$	
September		$.07\frac{1}{3}$	$.06\frac{5}{8}$	$.07$	$.07\frac{5}{8}$				$.07$	
October		$.07\frac{11}{16}$	$.07\frac{1}{4}$	$.07\frac{7}{16}$	$.07\frac{3}{4}$				$.07\frac{1}{2}$	
November		$.08\frac{5}{16}$	$.07\frac{9}{16}$	$.07\frac{11}{16}$	$.08$				$.07\frac{3}{4}$	
December		$.09\frac{3}{4}$	$.09$	$.09\frac{9}{16}$	$.10$				$.10$	
1893.										
August		$.08$	$.07\frac{1}{8}$	$.07\frac{5}{8}$	$.08\frac{1}{8}$				$.07\frac{9}{16}$	
September		$.07\frac{13}{16}$	$.06\frac{3}{4}$	$.07\frac{5}{16}$	$.07\frac{1}{2}$				$.07\frac{1}{4}$	
October		$.08\frac{1}{16}$	$.07\frac{7}{8}$	$.07\frac{3}{4}$	$.08\frac{1}{4}$				$.07\frac{13}{16}$	
November		$.08\frac{3}{16}$	$.07\frac{1}{2}$	$.07\frac{5}{8}$	$.08$				$.07\frac{11}{16}$	
December		$.08\frac{1}{16}$	$.07\frac{1}{4}$	$.07\frac{9}{16}$	$.07\frac{7}{8}$				$.07\frac{9}{16}$	
1894.										
August		$.06\frac{15}{16}$	$.06\frac{1}{2}$	$.06\frac{5}{8}$	$.07\frac{1}{4}$				$.06\frac{7}{8}$	
September		$.06\frac{7}{8}$	$.06\frac{3}{8}$	$.06\frac{7}{16}$	$.07$				$.06\frac{5}{8}$	
October		$.06\frac{1}{4}$	$.05\frac{5}{8}$	$.05\frac{9}{16}$	$.06\frac{1}{4}$				$.05\frac{3}{4}$	
November		$.05\frac{3}{4}$		$.05\frac{3}{16}$	$.05\frac{1}{2}$				$.05\frac{1}{4}$	
December		$.05\frac{13}{16}$	$.05\frac{1}{16}$	$.05\frac{5}{16}$	$.05\frac{5}{8}$				$.05\frac{3}{8}$	

EXPORTS OF THE PRODUCTS OF DOMESTIC AGRICULTURE FOR THE YEARS ENDING JUNE 30, 1890, 1891, 1892, 1893, 1894.

Article.	1890.		1891.		1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animals, living:										
Cattle .... number..	394,836	$31,261,131	374,679	$30,445,249	394,607	$35,099,095	287,094	$26,032,428	359,278	$33,461,922
Hogs .... do....	91,148	909,042	95,654	1,146,630	31,963	364,081	27,375	397,162	1,553	14,753
Horses .... do....	3,501	680,410	3,110	784,908	3,226	611,188	2,967	718,607	5,246	1,108,995
Mules .... do....	3,544	447,108	2,184	278,658	1,965	238,591	1,634	210,278	2,063	240,961
Sheep .... do....	67,521	243,077	60,947	261,109	46,960	161,105	37,260	126,394	132,370	832,763
All other and fowls	....	97,360	....	18,532	....	24,161	....	43,116	....	53,247
Animal matter:										
Bones, hoofs, horns and horn tips, strips, and waste	....	271,533	....	335,710	....	218,639	....	319,848	....	260,675
Casings for sausages	....	697,772	....	841,075	....	878,675	....	1,409,280	....	1,280,514
Eggs .... dozen..	380,884	58,675	363,116	64,259	183,063	32,374	143,489	33,207	163,061	27,497
Glue .... pounds..	728,696	88,484	986,552	110,292	580,815	66,403	736,446	74,722	999,052	101,372
Grease, grease scraps, and all soap-stock	....	1,506,819	....	2,038,886	....	1,298,598	....	1,067,723	....	1,380,299
Hair and manufactures of	....	344,558	....	394,544	....	370,169	....	459,648	....	353,729
Hides and skins other than furs	....	1,828,635	....	1,333,655	....	1,223,895	....	1,497,003	....	3,972,494
Honey	....	113,101	....	83,325	....	78,048	....	15,115	....	127,282
Oils—										
Lard .... gallons..	1,214,611	663,343	1,092,448	562,986	901,575	496,601	486,812	336,613	681,081	449,571
Other animal .... do....	727,732	457,926	512,253	317,594	278,954	144,119	212,266	106,275	270,835	149,801
Meat products—										
Beef products—										
Beef, canned .... pounds..	82,638,507	6,787,193	109,585,727	9,068,906	87,028,084	7,876,454	79,089,493	7,222,824	55,974,910	5,120,851
Beef, fresh .... do....	173,237,596	12,862,384	194,045,638	15,322,054	220,554,617	18,053,732	206,294,724	17,754,041	193,891,824	16,700,163
Beef, salted or pickled .do....	97,508,419	5,250,068	90,286,979	5,048,788	70,204,736	3,987,829	58,423,963	3,185,321	62,682,667	3,572,054
Beef, other cured .... do....	102,110	9,223	1,621,833	147,518	953,712	92,524	898,920	87,776	1,218,334	100,631
Tallow .... do....	112,745,370	5,242,158	111,689,251	5,501,049	89,780,010	4,425,630	61,819,153	3,129,059	54,661,524	2,766,164
Mutton .... do....	256,711	21,793	199,395	18,959	101,463	9,022	108,214	9,175	2,197,900	174,464
Oleomargarine—										
Imitation butter .... do....	2,535,926	297,264	1,986,743	255,024	1,610,837	195,587	3,479,322	416,386	3,898,950	475,003
The oil .... do....	68,218,098	6,476,258	80,231,035	7,859,130	91,581,703	9,011,889	113,939,363	11,207,250	123,295,895	11,942,842
Pork products—										
Bacon .... do....	531,899,677	39,149,635	514,675,577	37,404,989	507,919,830	39,334,933	391,758,175	35,781,470	416,657,577	38,338,843
Hams .... do....	76,591,279	7,907,125	84,410,108	8,245,685	76,856,559	7,757,717	82,178,154	9,933,096	86,970,571	9,845,062
Pork, fresh .... do....	279,463	15,406	818,875	56,358	377,746	30,246	912,644	79,317	1,168,647	92,095
Pork, salted or cured ..do....	79,788,868	4,753,488	81,317,364	4,787,343	80,336,481	4,792,049	52,459,722	4,116,946	63,575,881	5,067,773
Lard .... do....	471,083,598	33,455,520	498,343,927	34,414,323	460,045,776	33,201,621	365,693,501	34,643,993	447,566,867	40,089,809
Poultry and game	....	23,365	....	15,808	....	13,828	....	17,978	....	18,633
All other meat products	....	931,770	....	1,007,757	....	1,220,205	....	1,245,466	....	1,386,089

Dairy products—										
Butter.............pounds..	29,748,042	4,187,489	15,187,114	2,197,106	15,047,246	2,445,878	8,920,107	1,672,690	11,812,092	2,077,608
Cheese ....do....	95,376,053	8.591,042	82,133,876	7,405,376	82,100,221	7,676,657	81,350,923	7,624,648	73,852,134	7,180,331
Milk..........................		303,325		261,298		236,358		274,155		322,288
Wax, bees'.............pounds..	171,391	19,727	120,548	30,027	127,470	31,898	77,434	22,048	469,763	118,093
Wool, raw..................do....	231,042	33,543	291,922	39,423	202,456	30,664	91,858	14,808	520,247	90,676
Total value of animals and animal matter..................		175,986,750		178,104,333		181,730,463		171,285,866		189,295,287
Bread and breadstuffs:										
Barley ....bushels..	1,408,311	754,605	973,062	669,203	2,800,075	1,751,445	3,035,267	1,468,843	5,219,405	2,379,714
Bread and biscuits.........pounds..	15,035,540	766,476	15,541,655	838,848	14,449,625	775,596	14,583,967	752,353	15,185,175	723,873
Corn.........................bushels..	101,973,717	42,658,015	30,768,213	17,652,687	75,451,849	41,590,460	46,037,274	24,587,511	65,324,841	30,211,154
Corn meal....................barrels..	361,248	896,879	318,329	946,977	287,609	919,961	271,155	793,081	291,172	770,526
Oats ....bushels.	13,692,776	4,510,055	953,010	405,708	9,425,078	3,842,559	2,380,643	951,920	5,750,266	2,027,934
Oat meal.....................pounds..	25,460,322	784,879	7,736,873	221,316	20,908,190	555,957	5,762,701	160,660	9,719,337	238,528
Rye.........................bushels..	2,257,377	1,279,814	332,739	212,161	12,041,316	11,432,160	1,477,058	1,002,796	230,822	126,532
Rye flour...................barrels..	3,933	13,782	4,254	18,185	4,552	22,461	2,811	10,290	3,055	9,273
Wheat.......................bushels..	54,387,767	45,275,906	55,131,948	51,420,272	157,280,351	161,399,132	117,121,109	93,534,970	88,415,230	59,407,041
Wheat flour................barrels..	12,231,711	57,036,138	11,344,304	54,705,616	15,196,769	75,362,283	16,620,339	75,494,347	16,859,533	69,271,770
All other breadstuffs and preparations of, used as food.............		949,348		1,030,683		1,711,103		1,555,883		1,610,884
Total value of bread and breadstuffs		154,925.897		128,121,656		299,363,117		200,312,654		166,777,229
Cotton and cotton-seed oil:										
Cotton—										
Sea island..............pounds..	9,220,819	2,280,717	14,588,092	3,062,968	9,074,686	1,591,464	7,983,415	1,758,756	14,255,439	2,904,905
Other unmanufactured....do....	2,462,579,034	248,688,075	2,892,770,703	287,649,930	2,926,145,125	256,869,777	2,204,131,711	187,012,689	2,669,026,886	207,964,384
Cotton-seed oil..............gallons..	13,384,385	5,291,178	11,003,160	3,975,305	13,859,278	4.982,285	9,462,074	3,927,556	14,958,309	6,008,405
Total value of cotton and cotton-seed oil..................		256,259,970		294,688,203		263,443,526		192,699,001		216,877,694
Miscellaneous:										
Broom corn........................		111,147		172,191		218,133		163,105		210,742
Fruits and nuts—										
Apples, dried ....pounds..	20,861,462	1,038,682	6,973,168	409,605	26,042,063	1,288,102	7,966,819	482,085	2,846,645	168,054
Apples, green or ripe...barrels..	453,506	1,231,436	135,207	476,897	938,743	2,407,956	408,014	1,097,967	78,580	242,617
Fruits, preserved—										
Canned		698,321		703,880		1,558,820		1,137,660		660,723
Other.......................		59,401		93,996		214,738		224,381		211,215
All other, green, ripe, or dried ..		1,003,846		699,798		1,095,845		881,804		1,016,397
Nuts..............................		27,861		50,617		60,684		94,902		125,233
Hay............................tons..	36,274	567,558	28,066	470,228	35,201	582,838	33,084	519,640	54,446	890,654
Hops.........................pounds..	7,540,854	1,110,571	8,736,080	2,327,474	12,604,686	2,420,502	11,367,030	2,695,867	17,472,975	3,844,232
Oil cake and oil-cake meal.....do....	711,704,373	7,999,926	633,344,851	7,452,094	826,398,719	9,713,204	802,416,067	9,688,773	744,603,224	8,807,256
Oils—										
Linseed .... gallons..	89,288	55,036	76,789	48,267	112,386	54,020	103,936	54,356	92,861	48,550
Other vegetable..................		102,792		93,429		73,731		236,101		129,041

EXPORTS OF THE PRODUCTS OF DOMESTIC AGRICULTURE FOR THE YEARS ENDING JUNE 30, 1890, 1891, 1892, 1893, 1894—Continued.

Article.	1890.		1891.		1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Miscellaneous—Continued.										
Rice .... pounds..	388, 914	$20, 728	340, 620	$33, 012	....	....	....	....	763, 425	$19, 884
Seeds—										
Clover .... do....	26, 500, 578	1, 762, 034	20, 773, 884	1, 575, 039	19, 532, 411	$1, 636, 671	8, 189, 553	$988, 029	45, 418, 663	4, 540, 851
Cotton .... do....	7, 660, 601	74, 575	10, 108, 014	85, 315	12, 149, 261	86, 549	4, 519, 327	35, 809	5, 419, 056	41, 866
Flaxseed or linseed ..... bushels..	14, 678	19, 792	144, 848	184, 564	3, 613, 817	3, 915, 547	1, 837, 370	2, 195, 374	2, 047, 836	2, 426, 284
Timothy .... pounds..	11, 051, 053	473, 770	8, 757, 788	370, 151	10, 318, 074	381, 651	7, 077, 131	504, 937	10, 155, 867	449, 207
All other	....	307, 717	....	285, 830	....	231, 864	....	269, 580	....	484, 013
Tobacco—										
Leaf .... pounds..	244, 343, 740	21, 149, 869	236, 969, 589	20, 710, 911	240, 716, 150	20, 303, 245	248, 367, 258	22, 292, 704	268, 791, 312	22, 939, 356
Stems and trimmings ...... do....	11, 303, 286	329, 687	12, 263, 016	322, 848	14, 715, 927	366, 800	17, 715, 825	599, 195	21, 893, 680	1, 145, 878
Vegetables—										
Onions .... bushels..	80, 275	72, 760	57, 182	79, 993	59, 842	58, 121	57, 610	60, 878	68, 865	69, 823
Pease and beans .... do....	261, 212	558, 317	251, 063	473, 006	637, 972	945, 767	389, 913	745, 636	326, 748	576, 657
Potatoes .... do....	406, 618	269, 693	341, 189	316, 482	557, 022	361, 378	845, 720	700, 032	803, 111	651, 877
Canned	....	231, 265	....	286, 321	....	373, 068	....	242, 284	....	255, 857
All other, including pickles	....	225, 060	....	180, 173	....	159, 811	....	149, 167	....	190, 248
Wine—										
In bottles .... dozen..	7, 281	32, 350	11, 409	52, 392	15, 054	67, 686	11, 128	51, 654	13, 813	63, 860
Not in bottles .... gallons..	393, 323	238, 580	543, 292	319, 085	655, 795	371, 344	708, 558	369, 893	802, 192	380, 588
All other agricultural products	....	2, 875, 417	....	3, 563, 554	....	5, 843, 051	....	4, 603, 652	....	4, 821, 865
Total value of miscellaneous products	....	42, 648, 191	....	41, 837, 152	....	54, 791, 126	....	51, 085, 465	....	55, 412, 828
RECAPITULATION.										
Animals and animal matter	....	175, 986, 750	....	178, 104, 333	....	181, 730, 463	....	171, 285, 866	....	189, 295, 287
Bread and breadstuffs	....	154, 925, 897	....	128, 121, 656	....	299, 363, 117	....	200, 312, 654	....	166, 777, 229
Cotton and cotton-seed oil	....	256, 259, 970	....	294, 688, 203	....	263, 443, 526	....	192, 699, 001	....	216, 877, 694
Miscellaneous products	....	42, 648, 191	....	41, 837, 152	....	54, 791, 126	....	51, 085, 465	....	55, 412, 828
Total agricultural exports	....	629, 820, 808	....	642, 751, 344	....	799, 328, 232	....	615, 382, 986	....	628, 363, 038
Total exports	....	845, 293, 828	....	872, 270, 283	....	1, 015, 732, 011	....	831, 030, 785	....	869, 204, 937
Per cent of agricultural matter.	....	74. 51	....	73. 69	....	78. 69	....	74. 05	....	72. 29

IMPORTS OF AGRICULTURAL PRODUCTS FOR THE YEARS ENDING JUNE 30, 1890, 1891, 1892, 1893, 1894.

Articles.	1890.	1891.	1892.	1893.	1894.
Sugar and molasses:					
Sugar	$96, 094, 532	$105, 728, 216	$104, 408, 813	$116, 255, 784	$126, 871, 889
Molasses	5, 168, 795	2, 659, 172	2, 877, 744	1, 992, 334	1, 984, 778
Sugar drainings	3, 399	1, 349	....	....	....
Total sugar and molasses	101, 266, 726	108, 388, 737	107, 286, 557	118, 248, 118	128, 856, 667
Tea, coffee, and cocoa:					
Tea	12, 317, 493	13, 828, 993	14, 373, 222	13, 857, 482	14, 144, 243
Coffee	78, 267, 432	96, 123, 777	128, 041, 930	80, 485, 558	90, 314, 676
Cocoa and leaves and shells of	2, 312, 781	2, 817, 168	3, 221, 041	4, 017, 801	2, 402, 382
Unenumerated items	556, 931	603, 683	724, 007	683, 643	708, 709
Total tea, coffee, and cocoa	93, 454, 637	113, 373, 621	146, 360, 200	99, 044, 484	107, 570, 010
Animals and their products, except wool:					
Cattle	244, 747	102, 978	47, 466	45, 682	18, 704
Horses	4, 840, 485	3, 265, 254	2, 455, 868	2, 388, 267	1, 319, 572
Sheep	1, 268, 209	1, 219, 206	1, 440, 530	1, 682, 977	788, 181
All other and fowls	413, 491	357, 927	307, 752	525, 269	274, 789
Bristles	1, 286, 219	1, 357, 938	1, 455, 058	1, 508, 258	929, 231
Butter	13, 679	58, 541	16, 549	13, 479	23, 356
Cheese	1, 295, 506	1, 358, 752	1, 238, 166	1, 425, 927	1, 247, 198
Eggs	2, 074, 912	1, 185, 595	522, 240	392, 973	199, 536
Glue	471, 829	497, 340	495, 519	567, 756	400, 240
Grease	264, 089	430, 335	271, 421	419, 625	256, 287
Hair	2, 866, 231	2, 265, 714	1, 685, 562	2, 005, 796	839, 972
Hides	21, 881, 886	27, 930, 759	26, 850, 218	28, 347, 896	16, 786, 152
Hide cuttings, etc	348, 440	353, 943	303, 302	365, 525	280, 062
Hoofs, horns, etc	236, 648	587, 444	797, 529	554, 902	235, 232
Meats—					
Preserved	407, 038	521, 322	430, 048	558, 284	412, 666
All other	272, 199	144, 049	97, 893	115, 376	114, 901
Milk	102, 954	105, 633	95, 947	110, 186	102, 336
Oil, animal	6, 471	5, 531	12, 136	21, 327	1, 232
Sausage skins	494, 958	572, 817	566, 650	583, 217	495, 116
Unenumerated	478, 988	513, 171	559, 033	611, 351	519, 278
Total animals and their products, except wool	39, 268, 979	42, 834, 249	39, 648, 887	42, 244, 073	25, 244, 041
Fibers:					
Animal—					
Wools	15, 264, 083	18, 231, 372	19, 688, 108	21, 064, 180	6, 107, 438
Silk, unmanufactured	24, 325, 531	19, 076, 081	25, 059, 325	29, 836, 986	16, 234, 182
Vegetable—					
Cotton	1, 392, 728	2, 825, 004	3, 217, 521	4, 688, 799	3, 097, 297
Flax	2, 188, 021	1, 656, 779	1, 964, 163	1, 879, 152	1, 336, 845
Hemp and substitutes	7, 341, 956	7, 949, 650	7, 354, 088	9, 061, 855	4, 253, 173
Jute	3, 249, 926	3, 862, 858	3, 021, 174	2, 467, 828	1, 716, 298
Sisal grass and other vegetable substances	7, 064, 184	5, 829, 514	5, 187, 620	6, 005, 484	3, 742, 073
Fibers not elsewhere specified	697, 680	1, 987, 904	1, 597, 049	1, 957, 236	1, 115, 092
Total fibers	61, 524, 109	61, 419, 162	67, 089, 048	76, 961, 520	37, 602, 398
Miscellaneous:					
Breadstuffs—					
Barley	5, 629, 849	3, 222, 593	1, 592, 040	921, 605	358, 744
Corn	908	1, 651	10, 752	1, 265	1, 508
Oats	8, 950	5, 056	8, 224	8, 897	3, 928
Oatmeal	59, 300	31, 089	27, 942	25, 642	24, 483
Rye	115, 657	98, 227	67, 507	7, 055	37
Wheat	112, 303	431, 940	1, 955, 385	707, 053	769, 177
Wheat flour	5, 049	43, 180	4, 231	2, 223	1, 946
Breadstuffs and farinaceous substances, not elsewhere specified	1, 210, 982	1, 194, 473	1, 223, 066	1, 266, 835	1, 042, 064
Chicory	209, 283	342, 517	154, 954	208, 881	243, 408
Fruits and nuts	20, 747, 774	26, 015, 374	20, 968, 262	23, 689, 659	18, 754, 771
Hay	1, 143, 445	445, 461	715, 151	964, 755	761, 940
Hops	1, 053, 616	1, 797, 406	883, 701	1, 085, 407	484, 415
Indigo	1, 827, 937	1, 600, 630	1, 779, 716	3, 137, 511	1, 218, 576
Malt, barley	161, 666	78, 433	6, 148	4, 411	5, 676
Oils, vegetable—					
Fixed or expressed—					
Olive	819, 110	733, 489	876, 613	891, 424	909, 897
Other	1, 340, 551	1, 465, 001	2, 239, 540	2, 754, 372	1, 730, 797
Volatile or essential	1, 061, 631	1, 523, 491	1, 676, 064	1, 654, 036	1, 102, 108

IMPORTS OF AGRICULTURAL PRODUCTS FOR THE YEARS ENDING JUNE 30, 1890, 1891, 1892, 1893, 1894—Continued.

Articles.	1890.	1891.	1892.	1893.	1894.
Miscellaneous—Continued.					
Opium, crude	$1,183,712	$1,202,375	$1,029,203	$1,186,824	$1,691,914
Plants, trees, and shrubs	343,226	189,763	155,018	137,503	124,143
Rice and rice meal	2,540,674	4,559,540	3,030,883	2,790,151	2,374,835
Seeds	4,089,814	3,266,230	2,264,837	2,757,010	2,395,603
Spices—					
Ground	249,077	262,682	307,738	298,008	257,845
Unground—					
Nutmegs	534,340	686,019	750,813	613,743	395,977
Pepper	1,619,215	1,338,637	1,069,268	1,278,062	665,576
All other	820,439	865,882	920,006	1,110,197	943,155
Tobacco, leaf	17,605,192	13,284,162	10,332,423	14,702,440	10,985,386
Vanilla beans	559,867	594,744	803,696	763,935	727,853
Vegetables—					
Beans and pease	1,307,702	2,078,571	957,824	1,734,228	1,117,969
Potatoes	1,365,898	2,797,927	186,006	2,066,589	1,277,194
Pickles and sauces	386,307	511,163	421,292	454,099	341,135
All other—					
In their natural state, or in salt or brine	885,390	1,020,194	563,297	691,968	653,259
Prepared or preserved	510,077	668,519	754,808	639,805	505,510
Wines—					
Champagne and other sparkling	4,752,572	5,615,872	4,571,816	5,579,054	3,498,522
Still wines—					
In casks	2,450,174	2,641,816	2,464,484	2,505,024	1,817,813
In bottles	1,657,210	1,749,372	1,908,203	2,121,275	1,423,143
Unenumerated items	70,777	95,313	130,766	146,827	54,240
Total miscellaneous	78,439,674	82,458,792	66,811,677	78,907,776	58,664,487
RECAPITULATION.					
Sugar and molasses	101,266,726	108,388,737	107,286,557	118,248,118	128,856,667
Tea, coffee, and cocoa	93,454,637	113,373,621	146,360,200	99,044,484	107,570,010
Animals and their products, except wool	39,268,979	42,834,249	39,648,887	42,244,073	25,244,041
Fibers, animal and vegetable	61,524,109	61,419,162	67,089,048	76,961,520	37,602,398
Miscellaneous	78,439,674	82,458,792	66,811,677	78,907,776	58,664,487
Total agricultural	373,954,125	408,474,561	427,196,369	415,405,971	357,937,603
Total imports	789,310,409	844,916,196	827,402,462	866,400,922	654,994,622
Per cent of agricultural matter	47.38	48.34	51.63	47.95	54.65

Fertilizing constituents contained in a crop of cotton yielding 300 pounds of lint per acre.

Fertilizing constituents (calculated).	Pounds per acre.						
	In 300 pounds lint.	In 654 pounds seed.	In 404 pounds bolls.	In 575 pounds leaves.	In 658 pounds stems.	In 250 pounds roots.	In 2,841 pounds total crop.
Nitrogen	0.72	20.08	4.50	13.85	5.17	1.62	45.94
Phosphoric acid, P_2O_5	0.18	6.66	1.14	2.57	1.22	0.38	12.15
Potash, K_2O	2.22	7.63	12.20	6.57	7.74	2.75	39.11
Soda, Na_2O	0.08	0.12	0.19	1.61	0.65	0.38	3.03
Lime, CaO	0.46	1.22	3.75	31.57	5.59	1.36	43.95
Magnesia, MgO	0.41	3.26	1.01	5.73	2.43	0.80	13.64
Sulphuric acid, SO_2	0.26	0.84	1.75	3.38	0.74	0.28	7.25
Insoluble matter	0.08	0.15	1.14	6.43	0.89	0.55	9.24

	Pounds.
Wood charcoal	1
Sulphur	1
Sodium chloride	2
Sodium bicarbonate	2
Sodium hyposulphite	2
Sodium sulphate	1
Antimony sulphide	1

FARM PRICES ON DECEMBER 1, 1890, 1891, 1892, 1893, AND 1894.

States and Territories.	Corn (per bushel). 1890.	1891.	1892.	1893.	1894.	Wheat (per bushel). 1890.	1891.	1892.	1893.	1894.
	Cts.	Cts.	Cts.	Cts.	Cts.					
Maine	74	80	67	62	72	$1.15	$1.10	$1.02	$1.02	$0.79
New Hampshire	72	77	65	57	76	1.15	1.15	1.00	.85	.80
Vermont	72	76	64	61	69	1.11	1.14	.96	.85	.67
Massachusetts	70	78	62	62	61	1.15	......	.97	.....	.....
Rhode Island	72	79	63	69	75	......	......	......	.....	.....
Connecticut	70	76	62	64	68	1.10	1.06	.87	.....	.....
New York	65	66	60	55	61	1.00	1.00	.85	.76	.62
New Jersey	62	65	58	52	54	1.00	1.04	.83	.70	.61
Pennsylvania	60	57	57	49	55	.99	1.00	.81	.65	.56
Delaware	50	55	44	40	45	.96	1.00	.75	.60	.55
Maryland	50	53	45	44	50	.92	1.00	.74	.76	.54
Virginia	55	50	53	46	47	.96	1.00	.76	.63	.56
North Carolina	55	58	54	50	47	1.00	1.02	.89	.72	.65
South Carolina	70	70	57	60	65	1.05	1.10	.93	.98	.87
Georgia	69	69	56	56	58	1.10	1.10	.90	.90	.76
Florida	75	80	60	68	71	......	......	......	.....	.....
Alabama	68	63	52	59	53	1.09	1.10	.93	.88	.78
Mississippi	70	58	51	55	49	1.10	1.00	.90	.85	.75
Louisiana	70	60	50	57	62	......	......	......	.....	.....
Texas	72	55	45	54	56	.95	.87	.75	.58	.54
Arkansas	65	46	47	45	47	.98	.90	.80	.65	.55
Tennessee	52	43	43	39	39	.97	.93	.68	.57	.51
West Virginia	60	52	56	55	57	.95	.96	.75	.72	.60
Kentucky	49	40	40	43	44	.92	.90	.67	.57	.50
Ohio	51	41	42	40	43	.91	.92	.68	.57	.49
Michigan	55	48	46	45	50	.90	.91	.67	.57	.52
Indiana	47	38	40	36	37	.88	.86	.64	.53	.46
Illinois	43	37	37	31	39	.87	.85	.63	.51	.45
Wisconsin	45	44	38	35	45	.83	.84	.62	.54	.51
Minnesota	42	39	37	34	43	.81	.78	.61	.51	.49
Iowa	41	30	32	27	45	.80	.81	.60	.49	.50
Missouri	44	38	36	30	40	.83	.80	.58	.48	.43
Kansas	51	34	31	31	43	.77	.73	.52	.42	.44
Nebraska	48	26	28	27	50	.76	.73	.50	.40	.49
South Dakota	50	35	33	25	46	.70	.72	.51	.44	.46
North Dakota		40	40	38	44		.70	.52	.43	.43
Montana	70	....	70	70	82	.80	.84	.69	.60	.54
Wyoming	65	....	61	63	65	.82	.82	.66	.65	.63
Colorado	63	53	40	51	61	.81	.73	.58	.52	.65
New Mexico	73	72	72	71	75	.95	.82	.80	.75	.88
Arizona	70	....	65	66	100	.90	.75	.78	.65	1.00

States and Territories.	Oats (per bushel). 1890.	1891.	1892.	1893.	1894.	Barley (per bushel). 1890.	1891.	1892.	1893.	1894.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Maine	57	45	45	45	44	76	72	68	67	66
New Hampshire	56	46	44	43	49	81	74	74	70	63
Vermont	50	41	43	42	51	70	72	66	60	60
Massachusetts	55	47	48	42	43	77	75	75	90	63
Rhode Island	54	47	49	43	47	76	78	82	87	72
Connecticut	53	45	45	40	43	70	70	76	....	....
New York	50	38	39	30	39	78	65	75	60	56
New Jersey	50	40	41	35	38	....	....	....	....	....
Pennsylvania	48	37	40	35	38	70	64	57	50	48
Delaware	45	39	38	38	35	....	....	....	....	....
Maryland	44	38	38	35	39	....	....	....	55	....
Virginia	45	41	39	35	37	....	62	....	48	....
North Carolina	51	51	45	44	44	....	....	....	52	....
South Carolina	60	61	52	53	53	....	....	....	115	....
Georgia	60	60	52	52	51	....	....	....	115	....
Florida	61	62	55	55	61	....	....	....	....	....
Alabama	62	60	51	51	51	....	....	....	....	....
Mississippi	60	58	50	47	47	....	....	....	....	....
Louisiana	61	52	50	44	47	....	....	....	....	....
Texas	55	47	38	42	39	....	78	65	62	55
Arkansas	53	42	40	39	40	....	....	....	....	....
Tennessee	45	40	38	31	35	....	....	66	55	56
West Virginia	45	40	41	38	39	....	....	....	....	....
Kentucky	45	37	37	34	36	....	....	38	51	47
Ohio	42	33	35	30	31	70	60	57	47	48
Michigan	44	32	35	32	34	63	60	60	49	50
Indiana	41	32	34	28	30	65	59	52	45	45
Illinois	41	28	31	27	29	60	55	49	40	48
Wisconsin	40	28	29	27	30	58	55	50	43	45
Minnesota	37	27	28	26	30	55	43	42	36	41
Iowa	38	26	26	23	28	52	42	40	33	42
Missouri	39	29	30	25	29	57	57	42	40	51
Kansas	38	27	26	27	31	57	40	35	47	49
Nebraska	39	23	23	22	36	57	37	33	31	43
South Dakota	32	25	23	25	35	52	41	35	33	35
North Dakota		26	28	28	29		42	33	31	36
Montana	59	48	40	37	31	74	65	66	50	40
Wyoming	56	....	38	40	48	....	70	68	73	....
Colorado	50	38	34	37	46	76	56	54	50	58
New Mexico	57	55	56	51	50	....	70	65	58	70
Arizona	58	....	....	....	....	80	70	....	52	75

States and Territories.	Hay (per ton). 1890.	1891.	1892.	1893.	1894.	Cotton (per pound). 1890.	1891.	1892.	1893.	1894.
						Cts.	Cts.	Cts.	Cts.	Cts.
Maine	$9.25	$9.30	$12.80	$12.13	$9.60	....	....	....	....	....
New Hampshire	9.75	11.00	13.20	15.60	10.50	....	....	....	....	....
Vermont	8.70	9.00	10.00	10.63	9.94	....	....	....	....	....
Massachusetts	13.50	16.00	16.60	17.33	15.50	....	....	....	....	....
Rhode Island	14.00	16.25	17.40	19.60	16.33	....	....	....	....	....
Connecticut	13.50	15.75	16.50	17.50	15.56	....	....	....	....	....
New York	7.75	11.00	11.00	11.33	9.66	....	....	....	....	....
New Jersey	10.30	14.40	14.25	17.43	14.09	....	....	....	....	....
Pennsylvania	7.50	10.00	12.30	14.40	11.31	....	....	....	....	....
Delaware	10.00	12.00	12.33	17.00	15.00	....	....	....	....	....
Maryland	9.84	11.15	11.75	14.25	11.13	....	....	....	....	....
Virginia	10.70	11.00	11.50	13.09	11.89	8.7	7	8.6	7.1	5
North Carolina	11.91	11.00	10.55	11.11	10.93	8.7	7.4	8.6	7.2	4.8
South Carolina	13.00	12.18	11.30	9.67	10.75	8.7	7.4	8.6	7.1	5
Georgia	14.25	13.50	11.80	12.06	12.38	8.6	7.4	8.5	7.3	4.5
Florida	15.50	15.00	14.00	19.75	16.25	8.6	7.3	8.2	7.3	4.8
Alabama	13.50	12.38	10.80	11.24	9.51	8.6	7.3	8.5	7	4.8
Mississippi	11.40	11.22	9.91	9.61	9.67	8.8	7.3	8.5	7	4.1
Louisiana	10.20	11.58	9.80	9.00	10.64	8.8	7.3	8.4	7	4.3
Texas	9.50	8.75	8.56	9.60	7.62	8.4	7	8	6.9	4.5
Arkansas	10.30	10.57	8.74	9.37	8.83	8.5	7.3	8.5	6.8	4.8
Tennessee	10.00	11.30	10.40	10.76	11.27	8.4	7.3	8.5	6.5	4.5
West Virginia	8.50	9.17	10.50	12.25	10.66	....	....	....	....	....
Kentucky	9.00	10.15	9.50	10.16	10.47	....	....	....	....	....
Ohio	7.50	8.20	9.17	10.05	8.46	....	....	....	....	....
Michigan	8.00	11.00	8.40	9.16	9.04	....	....	....	....	....
Indiana	8.00	7.70	7.80	9.16	7.58	....	....	....	....	....
Illinois	7.60	7.72	7.53	8.86	8.33	....	....	....	....	....
Wisconsin	6.65	9.80	7.65	7.20	7.96	....	....	....	....	....
Minnesota	5.00	5.75	4.60	4.57	5.30	....	....	....	....	....
Iowa	6.75	5.50	5.25	6.16	7.39	....	....	....	....	....
Missouri	7.20	6.20	6.75	7.04	7.82	8.6	....	7.8	....	4.6
Kansas	5.18	3.62	4.40	4.69	5.25	....	....	....	....	....
Nebraska	5.00	3.17	4.27	4.87	7.12	....	....	....	....	....
South Dakota	4.50	4.20	3.40	3.67	4.28	....	....	....	....	....
North Dakota		4.00	4.10	3.72	3.87	....	....	....	....	....
Montana	10.50	8.50	8.95	7.89	7.17	....	....	....	....	....
Wyoming	......	9.00	6.40	8.00	10.00	....	....	....	....	....
Colorado	9.00	8.00	6.50	6.98	7.54	....	....	....	....	....
New Mexico	9.00	9.50	11.25	8.50	11.50	....	....	....	....	....
Arizona	7.50	......	10.50	8.25	12.00	....	....	....	....	....

FARM PRICES ON DECEMBER 1, 1890, 1891, 1892, 1893, AND 1894—Continued.

States and Territories.	Corn (per bushel).					Wheat (per bushel).					Oats (per bushel).					Barley (per bushel).					Hay (per ton).					Cotton (per pound).				
	1890.	1891.	1892.	1893.	1894.	1890.	1891.	1892.	1893.	1894.	1890.	1891.	1892.	1893.	1894.	1890.	1891.	1892.	1893.	1894.	1890.	1891.	1892.	1893.	1894.	1890.	1891.	1892.	1893.	1894.
	Cts.	Cts.	Cts.	Cts.	Cts.						Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.						Cts.	Cts.	Cts.	Cts.	Cts.
Utah	68	60	58	58	58	$0.78	$0.75	$0.62	$0.60	$0.53	55	42	40	33	34	75	60	52	45	46	$8.00	$5.50	$6.31	$5.17	$5.56	....	....	....	....	....
Nevada	....	....	....	....	....	.86	.87	.75	.73	.75	55	....	....	....	....	75	75	60	60	51	9.75	5.00	7.00	10.00	7.25	....	....	....	....	....
Idaho	....	....	70	71	59	.78	.84	.60	.60	.46	58	50	37	41	32	75	68	33	53	47	11.00	6.67	7.40	5.50	4.34	....	....	....	....	....
Washington	50	....	60	62	69	.76	.75	.58	.48	.39	47	41	35	35	31	68	60	45	39	32	12.00	10.50	9.00	9.17	7.38	....	....	....	....	....
Oregon	66	71	56	47	56	.75	.88	.64	.55	.43	50	41	37	37	28	70	48	46	40	33	10.00	8.00	8.92	8.10	5.86	....	....	....	....	....
California	65	71	55	50	57	.76	.95	.68	.53	.57	56	60	40	38	44	75	61	47	42	45	10.50	11.00	8.76	7.87	9.50	....	....	....	....	....
Oklahoma	....	....	....	....	....	....	....	....	....	.51	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.6
General average	50.6	40.6	39.3	36.5	45.7	.838	.839	.624	.538	.491	42.4	31.5	31.7	29.4	32.4	64.8	54	47.2	41.1	44.2	7.74	8.39	8.49	8.68	8.54	8.6	7.3	8.4	6.99	4.6

FREIGHT RATES IN EFFECT JANUARY 1, 1891, 1892, 1893, 1894, 1895, IN CENTS PER 100 POUNDS.

From—	To—	Wheat (car loads).					Corn (car loads).					Potatoes (car loads).					Wool, in bales (car loads).					Pickled pork, in barrels (car loads).				
		1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.
Cincinnati, Ohio	Boston, Mass	26½	26½	23½	23½	23½	26½	26½	23½	23½	23½	31	31	29	29	29	62½	62½	52	62½	62½	31	31	29	29	29
	New York, N. Y.	21½	21½	21½	21½	21½	21½	21½	21½	21½	21½	26	26	26	26	26	56½	56½	46	56½	56½	26	26	26	26	26
	Philadelphia, Pa.	19½	19½	19½	19½	19½	19½	19½	19½	19½	19½	24	24	24	24	24	54½	54½	44	54½	54½	24	24	24	24	24
	Baltimore, Md	18½	18½	18½	18½	18½	18½	18½	18½	18½	18½	23	23	23	23	23	53½	53½	43	53½	53½	23	23	23	23	23
Indianapolis, Ind.	Boston, Mass	28	28	25	25	25	28	28	25	25	25	33	33	31	31	31	66½	66½	56½	66½	66½	33	33	31	31	31
	New York, N. Y.	23	23	23	23	23	23	23	23	23	23	28	28	28	28	28	60½	60½	49½	60½	60½	28	28	28	28	28
	Philadelphia, Pa.	21	21	21	21	21	21	21	21	21	21	26	26	26	26	26	58½	58½	47½	58½	58½	26	26	26	26	26
	Baltimore, Md	20	20	20	20	20	20	20	20	20	20	25	25	25	25	25	57½	57½	46½	57½	57½	25	25	25	25	25
Chicago, Ill	Boston, Mass	30	30	27	27	27	30	30	27	27	27	35	35	33	33	33	71	71	59	71	71	35	35	33	33	33
	New York, N. Y.	25	25	25	25	25	25	25	25	25	25	30	30	30	30	30	65	65	53	65	65	30	30	30	30	30
	Philadelphia, Pa.	23	23	23	23	23	23	23	23	23	23	28	28	28	28	28	63	63	51	63	63	28	28	28	28	28
	Baltimore, Md	22	22	22	22	22	22	22	22	22	22	27	27	27	27	27	62	62	50	62	62	27	27	27	27	27
East St. Louis, Ill.	Boston, Mass	34	34	31	31	31	34	34	31	31	31	40	40	38	38	38	81½	81½	63½	81½	81½	40	40	38	38	38
	New York, N. Y.	29	29	29	29	29	29	29	29	29	29	35	35	35	35	35	75½	75½	61½	75½	75½	35	35	35	35	35
	Philadelphia, Pa	27	27	27	27	27	27	27	27	27	27	33	33	33	33	33	73½	73½	59½	73½	73½	33	33	33	33	33
	Baltimore, Md	26	26	26	26	26	26	26	26	26	26	32	32	32	32	32	72½	72½	58½	72½	72½	32	32	32	32	32

HUMAN FOODS.

Ordinary food materials, such as meat, fish, eggs, potatoes, wheat, etc., consist of—

Refuse.—As the bones of meat and fish, shells of shellfish, skins of potatoes, bran of wheat, etc.

Edible portion.—As the flesh of meat and fish, the white and yolk of eggs, wheat flour, etc. The edible portion consists of *water* and *nutritive ingredients* or *nutrients.*

The principal kinds of nutritive ingredients are *protein, fats, carbohydrates,* and *mineral matters.*

The water, refuse, and salt of salted meat and fish are called nonnutrients. In comparing the values of different food materials for nourishment they are left out of account.

Food supplies the wants of the body in several ways. It either—

Is used to form the tissues and fluids of the body;

Is used to repair the wastes of tissues;

Is stored in the body for future consumption;

Is consumed as fuel, its potential energy being transformed into heat or muscular energy, or other forms of energy required by the body; or,

In being consumed protects tissues or other food from consumption.

The fuel value of food.—Heat and muscular power are forms of force or energy. The energy is developed as the food is consumed in the body. The unit commonly used in this measurement is the calorie, the amount of heat which would raise the temperature of a pound of water 4° F.

The following general estimate has been made for the average amount of potential energy in 1 pound of each of the classes of nutrients:

	Calories.
In 1 pound of protein	1,860
In 1 pound of fats	4,220
In 1 pound of carbohydrates	1,860

In other words, when we compare the nutrients in respect to their fuel values, their capacities for yielding heat and mechanical power, a pound of protein of lean meat or albumen of egg is just about equivalent to a pound of sugar or starch, and a little over 2 pounds of either would be required to equal a pound of the fat of meat or butter or the body fat.

For further explanation see article on Food and Diet, page 357.

TABLE A.—*Composition of different food materials—refuse, water, nutrients—and fuel value per pound.*

Food materials.	Number of specimens analyzed.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.
			Water.	Nutrients.					
				Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	
ANIMAL FOODS AS PURCHASED.									
Beef:		*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Neck	14	0.27	0.47	0.26	0.14	0.11	....	0.01	730
Chuck	19	.15	.53	.32	.16	.15	....	.01	940
Shoulder	8	.17	.55	.28	.16	.11	....	.01	760
Shoulder clod with bone	2	.13	.57	.30	.17	.12	....	.01	830
Whole rib	17	.21	.44	.35	.13	.21	....	.01	1,140
Loin	11	.15	.52	.34	.15	.18	....	.01	1,030
Sirloin	10	.10	.54	.36	.17	.19	....	.01	1,100
Porterhouse	4	.12	.53	.35	.15	.19	....	.01	1,075
Rump	15	.20	.45	.35	.14	.21	....	.01	1,130
Round	17	.09	.62	.30	.18	.11	....	.01	780
Flank	11	.04	.54	.42	.17	.24	....	.01	1,335
Hind shank	12	.55	.31	.14	.09	.04	....	.004	355
Liver	3	....	.70	.30	.22	.05	0.02	.01	665
Heart	2	....	.63	.37	.16	.20	....	.01	1,160
Tongue	1	....	.64	.37	.17	.18	....	.01	1,085
Dried beef	5	....	.51	.49	.32	.07	.01	.10	885
Corned rump	3	.06	.60	.34	.16	.15	....	.03	935
Corned flank	2	.12	.44	.44	.12	.29	....	.03	1,460
Corned and canned	7	....	.54	.46	.27	.16	....	.04	1,170
Tongue, canned	2	.04	.46	.50	.20	.26	....	.04	1,475
Tripe, pickled	2	....	.88	.13	.10	.01	.01	.002	260

TABLE A.—*Composition of different food materials—refuse, water, etc.*—Continued.

Food materials.	Number of specimens analyzed.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.
			Water.	Nutrients.					
				Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	
ANIMAL FOODS AS PURCHASED—continued.									
Veal:		*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Shoulder	2	.17	.57	.26	.17	.09	....	.01	675
Chuck	6	.19	.60	.22	.16	.05	....	.01	510
Flank	6	....	.67	.33	.19	.13	....	.01	895
Loin (chops)	10	.18	.56	.26	.16	.09	....	.01	670
Leg (cutlet)	7	.61	.29	.10	.08	.02	....	.004	235
Liver	1	....	.74	.26	.21	.04	....	.01	560
Mutton:									
Neck	10	.26	.42	.33	.12	.20	....	.01	1,060
Loin (chops)	16	.14	.41	.45	.13	.31	....	.01	1,550
Shoulder	9	.22	.45	.32	.13	.19	....	.01	1,025
Hind leg	15	.18	.52	.31	.15	.15	....	.01	910
Pork:									
Chuck	2	.18	.42	.40	.14	.26	....	.01	1,335
Sparerib (chops)	10	.16	.45	.39	.14	.25	....	.01	1,300
Smoked shoulder	4	.14	.37	.49	.13	.33	....	.03	1,625
Smoked ham	14	.13	.38	.49	.07	.38	....	.04	1,725
Bacon	8	.09	.20	.72	.11	.57	....	.04	2,610
Salt pork	7	.08	.14	.78	.04	.69	....	.04	2,995
Pork sausage	5	....	.44	.56	.12	.40	.01	.02	1,945
Bologna sausage	6	....	.60	.40	.19	.17	.001	.04	1,080
Frankfurt sausage	6	....	.58	.42	.21	.17	.004	.04	1,110
Poultry:									
Chicken	1	.38	.45	.17	.15	.01	....	.01	330
Fowl (old hen)	1	.43	.38	.19	.11	.07	....	.01	510
Turkey	1	.32	.45	.23	.16	.06	....	.01	550
Fish, etc.:									
Fresh cod, dressed	3	.30	.59	.12	.11	.002	....	.01	205
Fresh mackerel, dressed	1	.41	.44	.16	.11	.04	....	.01	360
Bluefish	1	.49	.40	.11	.10	.01	....	.01	205
Shad, whole	7	.50	.35	.15	.09	.05	....	.01	375
Smelts, whole	2	.42	.46	.12	.10	.01	....	.01	230
Lake trout, dressed	1	.35	.45	.20	.12	.07	....	.01	510
Red snapper	2	.49	.40	.11	.10	.01	....	.01	205
Halibut, sections	3	.18	.62	.20	.15	.04	....	.01	465
Fresh salmon, dressed	1	.24	.51	.25	.15	.10	....	.01	675
Salt cod *a*	2	.25	.40	.18	.16	.004	....	.01	315
Salt cod, boned *b*	1	....	.54	.24	.22	.003	....	.02	425
Salt mackerel, dressed *c*	1	.33	.28	.32	.15	.15	....	.02	910
Canned salmon *d*	3	....	.62	.37	.20	.16	....	.01	1,035
Oysters, solids	4	....	.87	.13	.06	.02	.05	.01	260
Long clams, solids	4	....	.86	.14	.09	.01	.02	.03	240
Round clams, solids	1	....	.86	.14	.07	.004	.04	.03	215
Eggs with shell	4	.12	.63	.25	.13	.12	....	.01	720
Lard and cottolene	....	....	....	....	....	1.00	....	....	4,220
Oleomargarine	....	....	.11	.89	.01	.85	.004	.03	3,605
Dairy products:									
Milk	....	....	.87	.13	.04	.04	.05	.01	325
Skim milk	....	....	.90	.10	.04	.01	.05	.01	180
Butter	....	....	.11	.90	.01	.85	.01	.03	3,615
Cheese, whole milk	50	....	.34	.67	.25	.36	.02	.04	2,005
Cheese, skim milk	8	....	.46	.55	.31	.17	.02	.04	1,345
ANIMAL FOODS, EDIBLE PORTION.									
Beef:									
Neck	....	....	.64	.36	.20	.15	....	.01	1,005
Chuck	....	....	.63	.37	.18	.18	....	.01	1,105
Shoulder	....	....	.66	.34	.20	.14	....	.01	930
Shoulder clod	....	....	.65	.35	.20	.14	....	.01	950
Whole rib	....	....	.55	.45	.17	.27	....	.01	1,450
Loin	....	....	.61	.39	.18	.21	....	.01	1,210
Sirloin	....	....	.60	.40	.18	.21	....	.01	1,215
Porterhouse	....	....	.61	.40	.17	.21	....	.01	1,220
Rump	....	....	.56	.44	.17	.26	....	.01	1,430
Round	....	....	.68	.32	.20	.11	....	.01	845
Flank	....	....	.56	.44	.17	.26	....	.01	1,420
Hind shank	....	....	.69	.31	.20	.10	....	.01	780
Liver	....	....	.70	.30	.22	.05	.02	.01	665
Heart	....	....	.63	.37	.16	.20	....	.01	1,160
Tongue	....	....	.64	.37	.17	.18	....	.01	1,085
Dried beef	....	....	.51	.49	.32	.07	.01	.01	885
Corned rump	....	....	.58	.42	.15	.23	....	.03	1,270

a Salt, 17.2 per cent. *b* Salt, 21.5 per cent. *c* Salt, 7.1 per cent. *d* Salt, 1 per cent.

TABLE A.—*Composition of different food materials—refuse, water, etc.*—Continued.

Food materials.	Number of specimens analyzed.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.
			Water.	Nutrients.					
				Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	
ANIMAL FOODS, EDIBLE PORTION—continued.									
Beef—Continued.		*Pound*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Corned flank	......	......	.50	.50	.14	.33	......	.03	1,675
Corned and canned	......	......	.54	.46	.27	.16	......	.04	1,170
Tongue, canned	......	......	.47	.53	.21	.28	......	.05	1,540
Tripe, pickled	......	......	.88	.13	.10	.01	.01	.002	260
Veal:									
Shoulder	......	......	.68	.32	.20	.11	......	.01	820
Chuck	......	......	.73	.27	.19	.07	......	.01	630
Flank	......	......	.67	.33	.19	.13	......	.01	895
Loin (chops)	......	......	.69	.31	.20	.11	......	.01	820
Leg (cutlet)	......	......	.71	.29	.20	.08	......	.01	705
Liver	......	......	.74	.26	.21	.04	......	.01	560
Mutton:									
Neck	......	......	.56	.44	.17	.26	......	.01	1,410
Loin (chops)	......	......	.48	.52	.15	.36	......	.01	1,800
Shoulder	......	......	.59	.42	.17	.24	......	.01	1,310
Hind leg	......	......	.63	.37	.18	.18	......	.01	1,095
Pork:									
Chuck	......	......	.51	.49	.17	.31	......	.01	1,625
Sparerib (chops)	......	......	.53	.47	.17	.29	......	.01	1,545
Smoked shoulder	......	......	.43	.57	.15	.38	......	.04	1,890
Smoked ham	......	......	.43	.57	.16	.35	......	.05	1,800
Bacon	......	......	.22	.78	.12	.62	......	.04	2,855
Salt pork	......	......	.16	.84	.05	.75	......	.05	3,255
Pork sausage	......	......	.44	.56	.12	.40	.01	.02	1,920
Bologna sausage	......	......	.60	.40	.19	.17	.001	.04	1,080
Frankfurt sausage	......	......	.58	.42	.21	.17	.004	.04	1,110
Poultry:									
Chicken	......	......	.72	.28	.25	.02	......	.01	535
Fowl	......	......	.67	.33	.20	.13	......	.01	890
Turkey	......	......	.66	.34	.24	.09	......	.01	810
Fish, etc.:									
Fresh cod	......	......	.83	.17	.16	.004	......	.01	310
Fresh mackerel	......	......	.74	.26	.19	.06	......	.01	605
Bluefish	......	......	.79	.22	.19	.01	......	.01	405
Shad	......	......	.71	.29	.19	.10	......	.01	745
Smelts	......	......	.79	.21	.17	.02	......	.02	400
Lake trout	......	......	.69	.31	.18	.11	......	.01	820
Red snapper	......	......	.79	.22	.19	.01	......	.01	400
Halibut, sections	......	......	.75	.25	.18	.05	......	.01	560
Fresh salmon	......	......	.67	.33	.19	.13	......	.01	885
Salt cod [a]	......	......	.54	.23	.21	.004	......	.02	410
Salt cod, boned [b]	......	......	.54	.24	.22	.003	......	.02	425
Salt mackerel [c]	......	......	.42	.47	.22	.23	......	.03	1,365
Canned salmon [d]	......	......	.62	.37	.20	.16	......	.01	1,035
Oysters, solids	......	......	.87	.13	.06	.02	.04	.01	260
Long clams, solids	......	......	.86	.14	.09	.01	.02	.03	240
Round clams, solids	......	......	.86	.14	.07	.004	.04	.03	215
Eggs	......	......	.74	.26	.15	.10	......	.01	720
Lard and cottolene	......	......	......	1.00	......	1.00	......	......	4,220
Oleomargarine	......	......	.11	.89	.01	.85	.004	.03	3,605
Dairy products:									
Milk	......	......	.87	.13	.04	.04	.05	.01	325
Skim milk	......	......	.90	.10	.04	.01	.05	.01	180
Butter	......	......	.11	.90	.01	.85	.01	.03	3,615
Cheese, whole milk	......	......	.34	.67	.25	.36	.02	.04	2,005
Cheese, skim milk	......	......	.46	.55	.31	.17	.02	.04	1,495
VEGETABLE FOODS.									
Flour and meal:									
Wheat flour	22	......	.13	.88	.11	.01	.75	.01	1,645
Wheat flour ("entire wheat")	2	......	.13	.87	.14	.02	.70	.01	1,640
Graham flour	3	......	.13	.87	.12	.02	.72	.02	1,625
Rye flour	4	......	.13	.87	.07	.01	.79	.01	1,625
Buckwheat flour	9	......	.15	.85	.06	.01	.77	.02	1,585
Corn or maize meal	104	......	.15	.86	.09	.04	.71	.01	1,650
White hominy	2	......	.14	.87	.08	.004	.77	.004	1,620
Oatmeal	10	......	.08	.92	.15	.07	.68	.02	1,850
Rolled oats	4	......	.08	.92	.16	.08	.67	.02	1,855
Pearl barley	1	......	.12	.88	.08	.01	.78	.01	1,635

[a] Salt, 23 per cent. [b] Salt, 21.5 per cent. [c] Salt, 10.6 per cent. [d] Salt, 1 per cent.

TABLE A.—*Composition of different food materials—refuse, water, etc.*—Continued.

Food materials.	Number of specimens analyzed.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.
			Water.	Nutrients.					
				Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	
VEGETABLE FOODS—cont'd.		*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Rice	10		.12	.88	.07	.004	.79	.004	1,630
Beans, dry	6		.13	.87	.22	.02	.60	.03	1,605
Peanuts in shells	1	.33	.04	.63	.13	.22	.27	.01	1,660
Peanuts, "meats"	1		.06	.94	.20	.32	.40	.02	2,475
Bread, crackers, etc:									
Wheat bread	13		.32	.68	.10	.01	.55	.01	1,265
Graham bread	1		.34	.66	.10	.01	.53	.02	1,225
Graham crackers	1		.05	.95	.10	.14	.70	.02	2,050
Boston crackers	1		.08	.92	.11	.10	.69	.02	1,895
Milk or cream crackers	1		.07	.93	.09	.13	.69	.01	2,010
Oyster crackers	1		.04	.96	.11	.05	.78	.03	1,855
Macaroni and vermicelli	23		.11	.89	.12	.02	.73	.03	1,640
Starch			.02	.98			.98		1,820
Tapioca, pearl	1		.11	.89	.003	.002	.88	.003	1,655
Sugar, granulated				1.00			1.00		1,860
Molasses			.25	.75			.73	.02	1,360
Vegetables:									
Potatoes		.15	.67	.18	.02	.001	.15	.01	320
Potatoes, edible portion	12		.79	.21	.02	.001	.18	.01	375
Sweet potatoes		.13	.62	.25	.01	.003	.23	.01	460
Sweet potatoes, edible portion	6		.71	.29	.02	.004	.26	.01	530
Beets		.20	.71	.09	.01	.001	.07	.01	160
Beets, edible portion	12		.88	.12	.02	.001	.09	.01	200
Turnips		.30	.63	.07	.01	.001	.06	.01	130
Turnips, edible portion	7		.89	.11	.01	.002	.08	.01	185
Onions		.10	.79	.11	.01	.003	.09	.01	205
Onions, edible portion	6		.88	.12	.01	.003	.10	.01	225
Squash		.50	.44	.06	.004	.001	.05	.003	105
Squash, edible portion	3		.88	.12	.01	.002	.10	.01	215
Cucumbers		.15	.82	.03	.01	.002	.02	.004	60
Cucumbers, edible portion	2		.96	.04	.01	.002	.03	.01	70
Cabbage		.15	.78	.07	.02	.003	.04	.01	120
Cabbage, edible portion	4		.92	.08	.02	.003	.05	.01	140
Cauliflower	1		.92	.08	.02	.01	.05	.01	155
Eggplant	1		.93	.07	.01	.003	.05	.01	130
Lettuce	3		.93	.07	.02	.01	.04	.01	120
Spinach	1		.92	.08	.02	.01	.03	.02	120
Asparagus	3		.94	.06	.02	.002	.03	.01	105
Green peas	1		.78	.22	.04	.01	.16	.01	400
String beans	2		.87	.13	.02	.004	.10	.01	235
Lima beans, green	1		.69	.32	.07	.01	.22	.02	570
Green sweet corn	1		.81	.19	.03	.01	.14	.01	360
Tomatoes	14		.94	.06	.01	.004	.05	.01	115
Watermelon, flesh or pulp	1		.92	.08	.01	.01	.06	.003	160
Fruits, etc.:									
Apples		.25	.62	.13	.004	.01	.12	.004	250
Apples, edible portion	7		.82	.18	.01	.01	.16	.01	335
Bananas, with skin	1	.38	.46	.16	.01	.002	.15	.01	295
Bananas, with pulp	2		.70	.30	.02	.01	.27	.01	555
Cherries, flesh	1		.86	.14	.01	.01	.11	.01	265
Strawberries	19		.91	.09	.01	.01	.07	.01	175
Blackberries	1		.89	.11	.01	.02	.08	.01	245
Whortleberries	1		.82	.18	.01	.03	.14	.004	390
Cranberries	1		.88	.12	.004	.01	.11	.002	350
Grapes		.25	.56	.19	.01	.01	.16	.004	375
Grapes, edible portion	1		.75	.25	.02	.02	.21	.01	500
Lemons, flesh	2		.89	.11	.01	.01	.08	.01	210
Oranges, flesh	13		.88	.12	.01	.01	.09	.01	230
Canned:									
Baked beans, canned	12		.67	.33	.07	.03	.20	.02	645
Peas, canned	82		.85	.15	.04	.002	.10	.01	255
String beans, canned	18		.94	.06	.01	.001	.04	.01	85
Lima beans, canned	15		.80	.20	.04	.003	.14	.02	355
Squash, canned	2		.87	.13	.01	.003	.12	.004	250
Tomatoes, canned	11		.94	.06	.01	.002	.04	.01	110
Corn, canned	44		.75	.25	.03	.01	.20	.01	470
Succotash, canned	1		.76	.24	.04	.01	.19	.01	445

TABLE B.—*Nutrients obtained for 10 cents in different foods at ordinary prices.*

Food materials as purchased.	Prices per pound.	Ten cents will buy—				
		Total food material.	Nutrients.			Fuel value.
			Protein.	Fat.	Carbohydrates.	
ANIMAL FOODS.						
Beef:	*Cents.*	*Pounds.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Neck	4	2.50	0.36	0.28	....	1,825
Do	6	1.67	.24	.19	....	1,220
Do	8	1.25	.18	.14	....	910
Chuck	8	1.25	.19	.19	....	1,175
Do	10	1.00	.15	.15	....	940
Do	14	.71	.11	.11	....	695
Shoulder	6	1.67	.27	.18	....	1,270
Do	9	1.11	.18	.12	....	845
Do	12	.83	.14	.09	....	630
Rib	10	1.00	.13	.21	....	1,140
Do	12	.83	.11	.18	....	945
Do	16	.63	.08	.13	....	720
Sirloin	12	.83	.14	.16	....	915
Do	15	.67	.11	.13	....	735
Do	18	.55	.09	.10	....	605
Do	20	.50	.08	.09	....	550
Round	10	1.00	.18	.11	....	780
Do	12	.83	.15	.09	....	645
Do	15	.67	.12	.07	....	525
Liver	5	2.00	.43	.11	0.04	1,330
Do	8	1.25	.27	.07	.02	830
Dried and smoked	15	.67	.21	.05	....	595
Do	20	.50	.16	.03	....	445
Do	25	.40	.13	.03	....	355
Canned corned	10	1.00	.27	.16	....	1,170
Do	12	.83	.22	.13	....	970
Do	16	.63	.17	.10	....	735
Veal:						
Shoulder	8	1.25	.21	.11	....	845
Do	10	1.00	.17	.09	....	675
Do	14	.71	.12	.06	....	480
Loin (chops)	15	.67	.11	.06	....	445
Do	20	.50	.08	.04	....	335
Leg (cutlet)	15	.67	.05	.02	....	155
Do	20	.50	.04	.01	....	120
Mutton:						
Shoulder	5	2.00	.26	.37	....	2,050
Do	7	1.43	.19	.26	....	1,465
Do	10	1.00	.13	.19	....	1,025
Loin (chops)	8	1.25	.16	.39	....	1,935
Do	12	.83	.11	.26	....	1,285
Do	16	.63	.08	.19	....	975
Leg	8	1.25	.19	.19	....	1,140
Do	12	.83	.12	.12	....	755
Do	16	.63	.09	.09	....	575
Pork:						
Sparerib	10	1.00	.14	.25	....	1,300
Do	12	.83	.12	.20	....	1,080
Do	14	.71	.10	.17	....	925
Smoked ham	12	.83	.06	.31	....	1,430
Do	16	.63	.04	.24	....	1,090
Do	20	.50	.04	.19	....	860
Smoked shoulder	8	1.25	.16	.41	....	2,030
Do	10	1.00	.13	.33	....	1,625
Do	14	.71	.09	.23	....	1,150
Salt pork, fat	10	1.00	.04	.69	....	2,995
Do	14	.71	.03	.49	....	2,125
Pork sausage	8	1.25	.15	.50	.02	2,430
Do	10	1.00	.12	.40	.01	1,945
Do	12	.83	.10	.33	.01	1,615
Bologna sausage	8	1.25	.24	.22	....	1,350
Do	10	1.00	.19	.17	....	1,080
Fish:						
Fresh cod, dressed	6	1.67	.18	....	....	340
Do	8	1.22	.13	....	....	255
Do	12	.83	.09	....	....	170
Fresh mackerel, dressed	12	.83	.09	.03	....	300
Do	15	.67	.08	.02	....	240
Do	18	.55	.06	.02	....	200
Bluefish, dressed	8	1.25	.12	.01	....	255
Do	12	.83	.08	.01	....	170
Do	16	.63	.06	....	....	130
Halibut steaks	15	.67	.10	.03	....	310
Do	18	.55	.08	.02	....	255
Salmon	25	.40	.06	.04	....	270
Do	50	.20	.03	.02	....	135

TABLE B.—*Nutrients obtained for 10 cents in different foods at ordinary prices*—Cont'd.

Food materials as purchased.	Prices per pound.	Ten cents will buy— Total food material.	Nutrients. Protein.	Nutrients. Fat.	Nutrients. Carbohydrates.	Fuel value.
ANIMAL FOODS—continued.						
Fish—Continued.	*Cents.*	*Pounds.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Salt mackerel	8	1.25	.18	.19	....	1,135
Do	12	.83	.12	.13	....	755
Salt cod, dry	6	1.67	.28	.01	....	525
Do	8	1.25	.20	.01	....	395
Boned salt cod	9	1.11	.25	....	....	470
Do	10	1.00	.22	....	....	425
Oysters:						
30 cents a quart	15	.67	.04	.01	.03	175
40 cents a quart	20	.50	.03	.01	.02	130
50 cents a quart	25	.40	.03	.01	.01	105
Eggs:						
15 cents a dozen	10	1.00	.13	.12	....	720
20 cents a dozen	13⅓	.75	.09	.09	....	540
25 cents a dozen	16⅔	.60	.08	.07	....	430
30 cents a dozen	20	.50	.07	.06	....	360
Milk:						
Sweet—						
4 cents a quart	2	5.00	.18	.20	.24	1,625
6 cents a quart	3	3.33	.12	.13	.16	1,080
8 cents a quart	4	2.50	.09	.10	.12	815
Skim, 3 cents a quart	1½	6.67	.23	.03	.34	1,200
Butter	16	.63	....	.54	....	2,275
Do	24	.42	....	.36	....	1,520
Do	32	.31	....	.26	....	940
Cheese:						
Whole milk	12	.83	.23	.30	.01	1,665
Do	16	.63	.16	.23	.01	1,265
Skim milk	10	1.00	.31	.17	.16	1,345
VEGETABLE FOODS.						
Wheat flour	2	5.00	.55	.06	3.74	8,225
Do	2½	4.00	.44	.04	2.99	6,580
Do	3	3.33	.33	.03	2.49	5,480
Corn meal	2	5.00	.46	.18	3.56	8,250
Do	3	3.33	.31	.12	2.37	5,495
Oatmeal	3	3.33	.50	.24	2.27	6,160
Do	4	2.50	.38	.18	1.71	4,625
Do	5	2.00	.30	.14	1.36	3,700
Rice	5	2.00	.15	.01	1.59	3,260
Do	7	1.43	.11	.01	1.14	2,330
Wheat bread	4	2.50	.26	.03	1.38	3,160
Do	5	2.00	.22	.02	1.11	2,530
Do	6	1.67	.17	.02	.92	2,110
Do	8	1.25	.13	.01	.69	1,580
Boston crackers	5	2.00	.21	.20	1.37	3,790
Do	6	1.67	.18	.17	1.15	3,160
Milk crackers	6	1.67	.16	.22	1.16	3,355
Do	9	1.11	.10	.15	.77	2,230
Oyster crackers	6	1.67	.19	.08	1.29	3,095
Do	9	1.11	.13	.05	.86	2,060
Corn starch and tapioca	8	1.25	....	....	1.23	2,275
Do	10	1.00	....	....	.98	1,820
Sugar, granulated	4	2.50	....	....	2.50	4,650
Do	5	2.00	....	....	2.00	3,720
Do	6	1.67	....	....	1.67	3,105
Potatoes:						
45 cents a bushel	¾	13.33	.24	.01	2.03	4,265
60 cents a bushel	1	10.00	.18	.01	1.52	3,200
75 cents a bushel	1¼	8.00	.14	.01	1.22	2,560
90 cents a bushel	1½	6.67	.12	.01	1.01	2,135
Sweet potatoes:						
90 cents a bushel	1½	6.67	.09	.02	1.52	3,070
$1.20 a bushel	2	5.00	.06	.02	1.14	2,300
$1.50 a bushel	2½	4.00	.05	.01	.91	1,840
Turnips	1¼	8.00	.07	.01	.46	1,040
Beans	3	3.33	.74	.06	1.98	5,345
Do	4	2.50	.56	.05	1.49	4,010
Do	5	2.00	.45	.04	1.19	3,210

TABLE C.—*Prices used in estimating cost of daily dietaries.*

Food material.	Price per pound. Cheap.	Medium.	Expensive.
Beef:	*Cts.*	*Cts.*	*Cts.*
Neck	4	6	8
Chuck	8	10	14
Shoulder	6	9	12
Shoulder clod	9	10	12
Round	10	12	15
Liver	5	8	10
Canned corned	10	12	16
Corned	8	10	12
Dried	15	20	25
Mutton chops	8	12	16
Pork:			
Sparerib	10	12	14
Smoked ham	12	16	20
Salt pork	10	14	....
Sausage	8	10	12
Fish:			
Fresh cod	6	8	12
Salt cod	6	8	....
Boned cod	9	10	....
Salt mackerel	8	12	....
Canned salmon	12	16	20
Butter	16	24	32
Cheese	12	16	....
Milk—4, 6, and 8 cents quart	2	3	4

Food material.	Price per pound. Cheap.	Medium.	Expensive.
Eggs—15, 24, and 30 cents dozen	*Cts.* 10	*Cts.* 16	*Cts.* 20
Lard	8	10	12
Flours, etc.:			
Wheat flour	2	2½	3
Graham flour	3	4	....
Rye flour	2	3	....
Corn meal	2	3	....
Oatmeal	3	4	5
Rice	5	7	....
Bread, etc.:			
Wheat bread	4	6	8
Rye bread	4	6	....
Brown bread	4	5	6
Milk crackers	6	9	....
Boston crackers	5	6	....
Corn starch	9	10	....
Sugar	4	5	6
Molasses — 50, 60, and 70 cents gallon	6¼	7½	8¾
Vegetables:			
Potatoes—60, 75, and 90 cents bushel	1	1¼	1½

Food material.	Price per pound. Cheap.	Medium.	Expensive.
Vegetables—con'd.	*Cts.*	*Cts.*	*Cts.*
Sweet potatoes—$0.90, $1.20, and $1.50 bushel	1½	2	2½
Turnips—60 and 90 cents bushel	1	1½	....
Beets — 22, 30, and 38 cents peck	1½	2½	2½
Onions—15, 22, and 30 cents peck	1	2	3
Squash	2	3	4
Beans	3	4	5
Canned tomatoes	4	6	8
Fruit:			
Strawberries	4	7	10
Oranges	3	5	7
Bananas	3	4	5
Apples	1	1½	2
Grapes	3	8	12

TABLE D.—*Daily dietaries.—Food materials furnishing approximately the 0.28 pound of protein and 3,500 calories of energy of the standard for daily dietary of a man at moderate muscular work.*[1]

[Cost estimated from prices given in Table C.]

Food materials.	Amount.	Cost. Cheap.	Medium.	Expensive.	Nutrients. Total.	Protein.	Fat.	Carbohydrates.	Fuel value.
	Ounces.	*Cents.*	*Cents.*	*Cents.*	*Lbs.*	*Lb.*	*Lb.*	*Lbs.*	*Calories.*
Salt pork	½	0.3	0.4	0.4	0.02	....	0.02	....	95
Milk, 1 pint	16	2	3	4	.13	0.04	.04	0.05	325
Butter	½	.5	.8	1	.03	....	.03	....	115
Cheese	1	.8	1	1	.04	.02	.02	....	125
Potatoes	8	.5	.6	.7	.09	.01	....	.08	160
Beans	6	1.1	1.5	1.9	.31	.08	.01	.22	600
Flour	8	1	1.3	1.5	.44	.06	.01	.37	820
Corn meal	8	1	1.5	1.5	.43	.05	.02	.36	825
Rye meal	2	.3	.4	.4	.11	.01	....	.10	205
Sugar	1	.2	.3	.4	.06	....	....	.06	115
Molasses	2	.8	.9	1.1	.09	....	....	.09	165
Total	53	8.5	11.7	13.9	1.75	.27	.15	1.33	3,550
Salt cod	6	2.3	3	3	.06	.06	....	....	120
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Butter	2	2	3	4	.10	....	.10	....	450
Lard	½	.2	.3	.4	.03	....	.03	....	130
Salt pork	½	.3	.4	.4	.02	....	.02	....	95
Potatoes	6	.4	.5	.6	.07	.01	....	.06	120
Beans	7	1.3	1.7	2.2	.37	.10	.01	.26	700
Wheat flour	12	1.5	1.9	2.2	.65	.08	.01	.56	1,230
Oatmeal (or corn meal, 3 ounces)	2½	.5	.6	.8	.14	.02	.01	.11	290
Sugar	1½	.4	.5	.6	.09	....	....	.09	175
Total	46	9.9	13.4	16.2	1.59	.29	.20	1.10	3,475

[1] In some cases supplementary items are given to show the effect of the addition of particular food materials on the cost and nutritive value of a dietary.

TABLE D.—*Daily dietaries.—Food materials, etc.*—Continued.

[Cost estimated from prices given in Table C.]

Food materials.	Amount.	Cost.			Nutrients.				Fuel value.
		Cheap.	Medium.	Expensive.	Total.	Protein.	Fat.	Carbohydrates.	
	Ounces.	*Cents.*	*Cents.*	*Cents.*	*Lbs.*	*Lb.*	*Lb.*	*Lbs.*	*Calories.*
Pork, salt	½	.3	.4	.4	.02		.02		95
Canned corned beef	4	2.5	3	4	.11	.07	.04		290
Lard	½	.3	.3	.4	.03		.03		130
Milk	4	.5	.8	1	.03	.01	.01	.01	80
Butter	1	1	1.5	2	.05		.05		225
Egg, 1	2	1.2	2	2.5	.03	.02	.01		90
Potatoes	8	.5	.6	.8	.09	.01		.08	160
Beans	5	.9	1.3	1.6	.27	.07	.01	.19	500
Wheat flour	8	1	1.3	1.5	.44	.06	.01	.37	820
Corn meal	4	.5	.7	.7	.21	.02	.01	.18	410
Rye meal	4	.5	.7	.7	.22	.02		.20	405
Sugar	3	.8	.9	1.1	.19			.19	350
Total	44	10	13.5	16.7	1.69	.28	.19	1.22	3,555
Apples	8	.5	.8	1	.06			.06	125
Turnips	4	.3	.4	.4	.01			.01	35
Total	56	10.8	14.7	18.1	1.76	.28	.19	1.29	3,715
Beef neck	10	2.5	3.7	5	.15	.08	.07		455
Boned cod	4	2.3	2.5	2.5	.06	.06			105
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Butter	1½	1.5	2.3	3	.08		.08		340
Lard	1	.5	.6	.7	.06		.06		265
Potatoes	10	.6	.8	.9	.11	.01		.10	200
Flour	16	2	2.5	3	.87	.11	.01	.75	1,615
Rice	2	.6	.9	.9	.11	.01		.10	205
Sugar	1	.3	.3	.4	.06			.06	115
Total	53½	11.3	15.1	18.4	1.56	.29	.24	1.03	3,495
Bananas (or apples, 7)	6	1.1	1.5	1.9	.05			.05	110
Canned tomatoes (or grapes, 3 ounces)	10	2.5	3.7	5	.03			.03	70
Total	69½	14.9	20.3	25.3	1.64	.29	.24	1.11	3,675
Milk, 1 quart	32	4	6	8	.24	.07	.08	.09	650
Cheese	6	4.5	6	6	.22	.09	.13		750
Boston crackers	18	5.6	5.8	5.8	1.01	.12	.11	.78	2,130
Total	56	14.1	17.8	19.8	1.47	.28	.32	.87	3,530
Beef, shoulder	12	4.5	6.8	9	.20	.12	.08		570
Canned salmon	4	3	4	5	.09	.05	.04		260
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Butter	1	1	1.5	2	.05		.05		225
Lard	2	1	1.2	1.5	.13		.13		530
Potatoes	10	.6	.8	.9	.11	.01		.10	200
Flour	10	1.3	1.6	1.9	.55	.07	.01	.47	1,025
Rice	2½	.8	1.1	1.1	.13	.01		.12	255
Sugar	2	.5	.6	.8	.13			.13	235
Total	51½	13.7	19.1	24.2	1.45	.28	.33	.84	3,465
Canned tomatoes	6	1.5	2.2	3	.02			.02	40
Squash	3	.4	.6	.8	.01			.01	20
Total	60½	15.6	21.9	28	1.48	.28	.33	.87	3,525
Corned beef	9	4.5	5.6	6.8	.18	.09	.09		525
Milk, three-fourths pint	12	1.5	2.3	3	.10	.03	.03	.04	245
Butter	2	2	3	4	.10		.10		450
Egg, 1	2	1.3	2	2.5	.03	.02	.01		90
Potatoes	10	.6	.8	.9	.11	.01		.10	200
Turnips	5	.3	.4	.5	.02			.02	45
Flour	8	1	1.2	1.5	.44	.06	.01	.37	820
Rye bread	8	2	3	4	.31	.04		.27	640
Oatmeal	2	.4	.5	.6	.12	.02	.01	.09	230
Sugar	3	.7	.9	1.1	.19			.19	350
Total	61	14.3	19.7	24.9	1.60	.27	.25	1.08	3,595
Corned beef	8	4	5	6	.16	.08	.08		470
Pork sausage	4	2	2.5	3	.13	.03	.10		485
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Butter	1	1	1.5	2	.05		.05		225
Cheese	2	1.5	2	2	.07	.03	.04		250
Potatoes	12	.7	.9	1.1	.12	.01		.11	240

TABLE D.—*Daily dietaries.—Food materials, etc.*—Continued.

[Cost estimated from prices given in Table C.]

Food materials.	Amount.	Cost.			Nutrients.				Fuel value.
		Cheap.	Medium.	Expensive.	Total.	Protein.	Fat.	Carbohydrates.	
	Ounces.	*Cents.*	*Cents.*	*Cents.*	*Lbs.*	*Lb.*	*Lb.*	*Lbs.*	*Calories.*
Bread	10	2.5	3.8	5	.42	.06	.01	.35	290
Flour	6	.8	.9	1.1	.32	.04	....	.28	615
Molasses	3	1.2	1.4	1.6	.14	....	....	.14	250
Total	54	14.7	19.5	23.8	1.47	.27	.30	.90	2,990
Canned corned beef	3	1.9	2.3	3	.08	.05	.03	....	225
Fresh cod	8	3	4	6	.05	.05	....	....	100
Milk, 1 pint	16	2	3	4	.13	.04	.04	.05	325
Butter	2½	2.5	3.7	5	.13	....	.13	....	565
Potatoes	12	.7	.9	1.1	.12	.01	....	.11	240
Flour	8	1	1.2	1.5	.44	.06	.01	.37	820
Corn meal	3	.4	.6	.6	.16	.02	.01	.13	310
Graham flour	3	.6	.8	.8	.15	.02	....	.13	300
Wheatlet	2	.5	.6	.7	.11	.02	....	.09	200
Sugar	2	.5	.6	.7	.13	....	....	.13	235
Molasses	1	.4	.5	.6	.05	....	....	.05	85
Total	60½	13.5	18.2	24	1.55	.27	.22	1.06	3,405
Egg, 1	2	1.2	2	2.5	.03	.02	.01	....	90
Total	62½	14.7	20.2	26.5	1.58	.29	.23	1.06	3,495
Shoulder clod (or neck)	8	4.5	5	6	.17	.10	.07	....	465
Boned cod	4	2.3	2.5	2.5	.06	.06	....	....	105
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Butter	2½	2.5	3.7	5	.13	....	.13	....	565
Potatoes	7	.4	.6	7	.08	.01	....	.07	140
Lard	1	.5	.6	.7	.06	....	.06	....	265
Wheat flour	8	1	1.3	1.5	.44	.06	.01	.37	820
Oatmeal	2	.4	.5	.6	.12	.02	.01	.09	230
Brown bread	6	1.5	1.9	2.3	.17	.01	.01	.15	365
Cornstarch	½	.3	.3	.3	.03	....	....	.03	55
Sugar	3	.7	.9	1.1	.19	....	....	.19	350
Total	50	15.1	18.8	29	1.51	.28	.31	.92	3,525
Beef, round	12	7.5	9	11.3	.22	.14	.08	....	585
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Butter	2½	2.5	3.8	5	.13	....	.13	....	565
Potatoes	16	1	1.3	1.5	.17	.02	....	.15	320
Bread	8	2	3	4	.34	.05	.01	.28	630
Corn meal	7	.9	1.3	1.3	.37	.04	.02	.31	720
Sugar	3	.7	.9	1.1	.19	....	....	.19	350
Total	56½	15.6	20.8	26.2	1.48	.27	.26	.95	3,335
Bananas	6	1.1	1.5	1.9	.05	....	....	.05	110
Canned tomatoes	4	1	1.5	2	.01	....	....	.01	25
Beets	4	.4	.5	.6	.01	....	....	.02	40
Total	70½	18.1	24.3	30.7	1.55	.27	.26	1.03	3,510
Mutton chops	8	4	6	8	.22	.07	.15	....	775
Dried beef	3	2.8	3.8	4.7	.08	.06	.01	.01	165
Milk, three-fourths pint	12	1.5	2.3	3	.10	.03	.03	.04	245
Butter	2	2	3	4	.10	....	.10	....	450
Potatoes	10	.6	.8	.9	.11	.01	....	.10	200
Bread	10	2.5	3.7	5	.42	.06	.01	.35	790
Oatmeal	1	.2	.2	.3	.05	.01	....	.04	115
Milk crackers	2	.8	1.1	1.1	.12	.01	.02	.09	250
Flour	3	.4	.5	.6	.16	.02	....	.14	310
Sugar	1	.2	.3	.4	.06	....	....	.06	115
Total	52	15	21.7	28	1.42	.27	.32	.83	3,415
Egg, 1	2	1.3	2	2.5	.03	.02	.01	....	90
Squash	4	.5	.8	1	.01	....	....	.01	25
Strawberries (or oranges, 6 ounces)	6	1.5	2.6	3.7	.03	....	....	.03	65
Total	64	18.3	27.1	35.2	1.49	.29	.33	.87	3,595
Pork, ham	8	6	8	10	.23	.04	.19	....	860
Beef liver	6	1.9	3	3.8	.11	.08	.02	.01	250
Milk, 1¼ pints	20	2.5	3.8	5	.16	.05	.05	.06	405
Butter	1	1	1.5	2	.05	....	.05	....	225
Potatoes	12	.7	.9	1.1	.12	.01	....	.11	240

TABLE D.—*Daily dietaries.—Food materials, etc.*—Continued.

[Cost estimated from prices given in Table C.]

Food materials.	Amount.	Cost.			Nutrients.				Fuel value.
		Cheap.	Medium.	Expensive.	Total.	Protein.	Fat.	Carbohydrates.	
	Ounces.	*Cents.*	*Cents.*	*Cents.*	*Lbs.*	*Lb.*	*Lb.*	*Lbs.*	*Calories.*
Flour	8	1	1.3	1.5	.44	.06	.01	.37	820
Corn meal	4	.5	.7	.7	.21	.02	.01	.18	410
Sugar	2	.5	.6	.8	.13			.13	235
Total	61	14.1	19.8	24.9	1.45	.26	.33	.86	3,445
Egg, 1	2	1.3	2	2.5	.03	.02	.01		90
Total	63	15.4	21.8	27.4	1.48	.28	.34	.86	3,535
Beef, chuck	10	5	6.2	8.7	.20	.10	.10		590
Butter	1½	1.5	2.3	3	.05		.08		340
Cheese	3	2.2	3	3	.12	.05	.07		375
Potatoes	12	.8	.9	1.1	.12	.01		.11	240
Bread	16	4	6	8	.66	.10	.01	.55	1,265
Milk crackers	4	1.5	2.3	2.3	.22	.02	.03	.17	500
Sugar	1	.3	.3	.4	.06			.06	115
Total	47½	15.3	21	26.5	1.43	.28	.29	.89	3,425
Apples	10	.6	.9	1.3	.08			.08	155
Turnips	2	.1	.2	.2	.01			.01	15
Total	59½	16	22.1	28	1.52	.28	.29	.98	3,595
Beef, round	6	3.8	4.5	5.6	.11	.07	.04		295
Dried beef	3	2.8	3.7	4.7	.08	.06	.01	.01	165
Milk, three-fourths pint	12	1.5	2.2	3	.10	.03	.03	.04	245
Butter	3	3	4.5	6	.16		.16		680
Egg, 1	2	1.2	2	2.5	.03	.02	.01		90
Potatoes	10	.6	.8	.9	.11	.01		.10	200
Wheat flour	3	.4	.5	.6	.16	.02		.14	310
Bread	8	2	3	4	.34	.05	.01	.28	630
Corn meal	4	.5	.8	.8	.21	.02	.01	.18	410
Sugar	2½	.6	.8	.9	.16			.16	295
Total	53½	16.4	22.8	29	1.46	.28	.27	.91	3,320
Tapioca	1½	.8	.9	.9	.07			.07	155
Apples	4	.2	.4	.5	.03			.03	60
Total	59	17.4	24.1	30.4	1.56	.28	.27	1.01	3,535
Constant:									
Butter	½	.5	.7	1	.03		.03		115
Milk, one-half pint	8	1.	1.5	2	.06	.02	.02	.02	165
Potatoes	12	.8	.9	1.1	.12	.01		.11	240
Wheat flour	12	1.5	1.9	2.3	.65	.08	.01	.56	1,230
Corn meal	6	.7	1.1	1.1	.31	.03	.01	.27	620
Milk crackers	2	.8	1.1	1.1	.12	.01	.02	.09	250
Sugar	1	.3	.3	.4	.06			.06	115
Total constant	41½	5.6	7.5	9	1.35	.15	.09	1.11	2,735
Variable A:[1]									
Beef, sirloin	9	6.7	9	11.2	.20	.09	.11		620
Dried beef	2	1.9	2.5	3.1	.06	.04	.01	.01	110
Total	52½	14.2	19	23.3	1.61	.28	.21	1.12	3,465
Variable B:[1]									
Beef, neck	6	1.5	2.3	3	.09	.05	.04		275
Canned corned beef	4	2.5	3	4	.11	.07	.04		290
Oatmeal	1½	.3	.4	.5	.08	.01	.01	.06	175
Total	53	9.9	13.2	16.5	1.63	.28	.18	1.17	3,475
Variable C:[1]									
Salt cod	5	1.9	2.5	2.5	.05	.05			100
Beans	6	1.1	1.5	1.9	.31	.08	.01	.22	600
Total	52½	8.6	11.5	13.4	1.71	.28	.10	1.33	3,435
Constant:									
Salt mackerel	4	2	3	3	.08	.04	.04		230
Butter	2	2	3	4	.10		.10		450
Potatoes	16	1	1.2	1.5	.17	.02		.15	320
Wheat flour	8	1	1.2	1.5	.44	.06	.01	.37	820

[1] To make a complete dietary the totals of variable items should be added to totals of the preceding constants.

TABLE D.—*Daily dietaries.—Food materials, etc.*—Continued.

[Cost estimated from prices given in Table C.]

Food materials.	Amount.	Cost.			Nutrients.				Fuel value.
		Cheap.	Medium	Expensive.	Total.	Protein.	Fat.	Carbohydrates.	
Constant—Continued.	*Ounces.*	*Cents.*	*Cents.*	*Cents.*	*Lbs.*	*Lb.*	*Lb.*	*Lbs.*	*Calories.*
Corn meal	6	.8	1.1	1.1	.31	.03	.01	.27	620
Oatmeal	2	.4	.5	.6	.12	.02	.01	.09	230
Total constant	38	7.2	10	11.7	1.21	.17	.17	.88	2,670
Variable A: [1]									
Beef, sirloin	9	6.7	9	11.3	.20	.09	.11	....	620
Milk, one-fourth pint	4	.5	.8	1	.03	.01	.01	.01	80
Sugar	1½	.4	.5	.5	.09	....	....	.09	175
Total	52½	14.8	20.3	24.5	1.54	.27	.29	.98	3,545
Variable B: [1]									
Beef, round	8	5	6	7.5	.14	.09	.05	....	390
Milk, three-eighths pint	6	.8	1.1	1.5	.05	.01	.02	.02	120
Sugar	2½	.6	.8	.9	.16	....	....	.16	295
Total	54½	13.6	17.9	21.6	1.57	.27	.24	1.06	3,475
Variable C: [1]									
Beef liver	7	2.2	3.5	4.4	.12	.09	.02	.01	290
Milk, one-half pint	8	1	1.5	2	.06	.02	.02	.02	165
Sugar	3	.7	.9	1.1	.19	....	....	.19	350
Total	56	11.1	15.9	19.2	1.59	.28	.21	1.10	3,475

[1] To make a complete dietary the totals of variable items should be added to totals of the preceding constants.

STANDARDS FOR DAILY DIETARIES FOR PEOPLE OF DIFFERENT CLASSES.

The figures of the following tables represent the amounts of nutrients which different investigators have estimated to be proper for the daily food of people of different classes. Those of the first table are compiled from European sources; Nos. 1-6 are from investigations mainly by Voit, Förster, and Cammerer, in Germany; Nos. 7 and 8 are the well-known standards of Professor Voit, of Munich; No. 9 is by Moleschott, in Italy; No. 10, by Wolff, in Germany; and Nos. 11-15, by Playfair, in England.

The figures for American standards are proposed by Atwater. They are based upon the European and American data. They differ from the European standards mainly in that the quantities are more liberal and that they are expressed simply in terms of protein and energy.

TABLE E.—*European standards for daily dietaries.*

	Class.	Nutrients.			Fuel value.	Nutritive ratio.
		Protein.	Fats.	Carbohydrates.		
		Pound.	*Pound.*	*Pounds.*	*Calories.*	
1	Children, 1 to 2 years, average	0.06	0.08	0.17	765	1 : 5.7
2	Children, 2 to 6 years, average	.12	.09	.44	1,420	1 : 5.3
3	Children, 6 to 15 years, average	.17	.10	.72	2,040	1 : 5.6
4	Aged woman	.18	.11	.57	1,860	1 : 4.7
5	Aged man	.22	.15	.77	2,475	1 : 5.0
6	Woman at moderate work	.20	.10	.88	2,425	1 : 5.4
7	Man at moderate work (Voit)	.26	.12	1.10	3,055	1 : 5.3
8	Man at hard work (Voit)	.32	.22	.99	3,370	1 : 4.7
9	Man at moderate work (Moleschott)	.29	.09	1.21	3,160	1 : 4.9
10	Man at moderate work (Wolff)	.28	.08	1.19	3,030	1 : 4.9
11	Subsistence diet (Playfair)	.13	.03	.75	1,760	1 : 6.5
12	Diet in quietude (Playfair)	.16	.06	.75	1,950	1 : 5.7
13	Adults in full health (Playfair)	.26	.11	1.17	3,140	1 : 5.4
14	Active laborers (Playfair)	.34	.16	1.25	3,630	1 : 4.7
15	Hard-worked laborers (Playfair)	.41	.16	1.25	3,750	1 : 3.9

TABLE F.—*American standards for daily dietaries.*

Class.	Protein.	Fuel value.	Nutritive ratio.
	Grams.	*Calories.*	
Woman with light muscular exercise	90	2,400	1 : 5.5
Woman with moderate muscular work	100	2,700	1 : 5.6
Man without muscular work } Man with light muscular work }	112	3,000	1 : 5.5
Man with moderate muscular work	125	3,500	1 : 5.8
Man with hard muscular work	150	4,500	1 : 6.3

FEEDING STUFFS (FOR ANIMALS).

EXPLANATIONS OF TERMS USED IN THE TABLE.

Water.—All feeding stuffs contain water. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorine, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is therefore stored up in the animal's body; the rest is voided in the manure.

Protein (or nitrogenous materials) is the name of a group of materials containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, and the casein and albumen of milk, etc., and is one of the most important constituents of feeding stuffs.

Fiber.—Fiber, sometimes called cellulose, is the framework of plants, and is, as a rule, the most indigestible constituents of feeding stuffs. The coarse fodders, such as hay and straw, contain a large proportion of fiber, and are, for this reason, less digestible than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains. The nitrogen-free extract and fiber are usually classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the system to produce heat and energy.

Fat, or the materials dissolved from a feeding stuff by ether, is an impure product, and includes, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

Composition of feeding stuffs.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
GREEN FODDER.						
Corn fodder, all varieties:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Minimum	51.5	0.6	0.5	1.9	3	0.1
Maximum	93.6	2.6	4	11.4	36.3	1.6
Average	79.3	1.2	1.8	5	12.2	.5
Rye fodder, average	76.6	1.8	2.6	11.6	6.8	.6
Oat fodder, average	62.2	2.5	3.4	11.2	19.3	1.4
Redtop (*Agrostis vulgaris*),a in bloom, average	65.3	2.3	2.8	11	17.7	.9
Tall oat grass (*Arrhenatherum avenaceum*),b average	69.5	2	2.4	9.4	15.8	.9
Orchard grass (*Dactylis glomerata*), average	73	2	2.6	8.2	13.3	.9
Meadow fescue (*Festuca pratensis*), average	69.9	1.8	2.4	10.8	14.3	.8
Italian rye grass (*Lolium italicum*), average	73.2	2.5	3.1	6.8	13.3	1.3
Timothy (*Phleum pratense*),c at different stages:						
Minimum	47	1.4	1.3	5.1	10.1	.6
Maximum	78.7	3.2	3.8	19.4	28.6	2
Average	61.6	2.1	3.1	11.8	20.2	1.2
Kentucky blue grass (*Poa pratensis*),d at different stages:						
Minimum	51.7	1.6	2.4	3.8	6.5	.8
Maximum	82.5	4.8	7.2	14.8	26.6	1.9
Average	65.1	2.8	4.1	9.1	17.6	1.3
Hungarian grass (*Setaria*), average	71.1	1.7	3.1	9.2	14.2	.7

a Herd's grass of Pennsylvania.
b Meadow oat grass.
c Herd's grass of New England and New York.
d June grass.

Composition of feeding stuffs—Continued.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
GREEN FODDER—continued.						
Red clover (*Trifolium pratense*), at different stages:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Minimum	47.1	.9	1.7	1.8	3.5	.3
Maximum	91.8	4	7.1	14.7	25.8	1.8
Average	70.8	2.1	4.4	8.1	13.5	1.1
Alsike clover (*Trifolium hybridum*),*a* average	74.8	2	3.9	7.4	11	.9
Crimson clover (*Trifolium incarnatum*), average	80.9	1.7	3.1	5.2	8.4	.7
Alfalfa (*Medicago sativa*),*b* at different stages:						
Minimum	49.3	1.8	3.5	2.5	10.8	.6
Maximum	82	5.1	7.7	14.8	11.5	1.2
Average	71.8	2.7	4.8	7.4	12.3	1
Serradella (*Ornithopus sativus*), average	79.5	3.2	2.7	5.4	8.6	.7
Cowpea, average	83.6	1.7	2.4	4.8	7.1	.4
Soja bean (*Soja hispida*), average	75.1	2.6	4	6.7	10.6	1
Horse bean (*Vicia faba*), average	84.2	1.2	2.8	4.9	6.5	.4
Flat pea (*Lathyrus sylvestris*), average	66.7	2.9	8.7	7.9	12.2	1.6
Rape, average	84.5	2	2.3	2.6	8.4	.5
SILAGE.						
Corn silage:						
Minimum	62.4	.3	.7	3	5.1	.2
Maximum	87.7	3.3	3.6	10.5	24.2	2
Average	79.1	1.4	1.7	6	11	.8
Red-clover silage, average	72	2.6	4.2	8.4	11.6	1.2
Soja-bean silage, average	74.2	2.8	4.1	9.7	6.9	2.2
Cowpea-vine silage, average	79.3	2.9	2.7	6	7.6	1.5
HAY AND DRY COARSE FODDER.						
Corn fodder,*c* field cured:						
Minimum	22.9	1.5	2.7	7.5	20.6	.6
Maximum	60.2	5.5	6.9	24.7	47.8	2.5
Average	42.2	2.7	4.5	14.3	34.7	1.6
Corn leaves, field cured, average	30	5.5	6	21.4	35.7	1.4
Corn husks, field cured, average	50.9	1.8	2.5	15.8	28.3	.7
Corn stover,*d* field cured, average	40.5	3.4	3.8	19.7	31.5	1.1
Hay from:						
Redtop,*e* cut at different stages—						
Minimum	6.8	3.8	5.9	24	44.8	1.4
Maximum	11.6	7	10.4	31.8	50.4	3.2
Average	8.9	5.2	7.9	28.6	47.5	1.9
Orchard grass, average	9.9	6	8.1	32.4	41	2.6
Timothy,*f* all analyses—						
Minimum	6.1	2.5	3.8	22.2	34.3	1
Maximum	28.9	6.3	9.8	38.5	58.5	4
Average	13.2	4.4	5.9	29	45	2.5
Kentucky blue grass—						
Minimum	14.3	4.5	5.3	17.7	31.8	2
Maximum	32.8	7.8	12.9	26.8	51.1	4.2
Average	21.2	6.3	7.8	23	37.8	3.9
Hungarian grass, average	7.7	6	7.5	27.7	49	2.1
Meadow fescue, average	20	6.8	7	25.9	38.4	2.7
Italian rye grass, average	8.5	6.9	7.5	30.5	45	1.7
Mixed grasses—						
Minimum	6.5	2.1	4.8	21	33.4	1.3
Maximum	33.4	6.9	12.1	38.4	50.8	4.9
Average	15.3	5.5	7.4	27.2	42.1	2.5
Rowen (mixed)*g*—						
Minimum	8.2	5.1	9.6	20.1	33.6	2.2
Maximum	24.4	7.2	14.8	20	44.3	4.5
Average	16.6	6.8	11.6	22.5	39.4	3.1
Mixed grasses and clovers—						
Minimum	8.2	3.9	5.5	19.7	31.8	1.5
Maximum	15.9	9.6	14.4	35.1	48.9	3.1
Average	12.9	5.5	10.1	27.6	41.3	2.6
Red clover—						
Minimum	6	3.9	10	15.6	27.3	1.5
Maximum	31.3	8.3	20.2	35.7	52.2	5.9
Average	15.3	6.2	12.3	24.8	38.1	3.3
Alsike clover, average	9.7	8.3	12.8	25.6	40.7	2.9
White clover (*Trifolium repens*), average	9.7	8.3	15.7	24.1	39.3	2.9
Crimson clover, average	9.6	8.6	15.2	27.2	36.6	2.8
Japan clover (*Lespedeza striata*), average	11	8.5	13.8	24	39	3.7
Vetch, average	11.3	7.9	17	25.4	36.1	2.3

a Swedish clover.
b Lucern.
c Entire plant.
d What is left after the ears are harvested.
e Herd's grass of Pennsylvania.
f Herd's grass of New England and New York.
g Second cut of hay.

Composition of feeding stuffs—Continued.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
HAY AND DRY COARSE FODDER—continued.						
Hay from:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Serradella, average	9.2	7.2	15.2	21.6	44.2	6.2
Alfalfa, average *a*	8.4	7.4	14.3	25	42.7	2.2
Cowpea, average	10.7	7.5	16.6	20.1	42.2	2.2
Soja bean, average	11.3	7.2	15.4	22.3	38.6	5.2
Flat pea (*Lathyrus*), average	8.4	7.9	22.9	26.2	31.4	3.2
Peanut vines (without nuts), average	7.6	10.8	10.7	23.6	42.7	4.6
Soja-bean straw, average	10.1	5.8	4.6	40.4	37.4	1.7
Horse-bean straw, average	9.2	8.7	8.8	37.6	34.3	1.4
Wheat straw:						
Minimum	6.5	3	2.9	34.3	31	.8
Maximum	17.9	7	5	42.7	50.6	1.8
Average	9.6	4.2	3.4	38.1	43.4	1.3
Rye straw, average	7.1	3.2	3	38.9	46.6	1.2
Oat straw:						
Minimum	6.5	3.7	2.7	31.8	33.5	1.7
Maximum	11.4	6.7	6.9	45.1	46.6	3.2
Average	9.2	5.1	4	37	42.4	2.3
Buckwheat straw, average	9.9	5.5	5.2	43	35.1	1.3
ROOTS AND TUBERS.						
Sugar beets, average	86.5	.9	1.8	.9	9.8	.1
Mangel-wurzels, average	90.9	1.1	1.4	.9	5.5	.2
Ruta-bagas, average	88.6	1.2	1.2	1.3	7.5	.2
Carrots, average	88.6	1	1.1	1.3	7.6	.4
Artichokes, average	79.5	1	2.6	.8	15.9	.2
GRAINS AND OTHER SEEDS.						
Corn kernels, all varieties and analyses:						
Minimum	4.5	1	7	.7	61.8	3.1
Maximum	20.7	2.6	15.3	5.2	76.7	9.3
Average	10.9	1.5	10.5	2.1	69.6	5.4
Barley:						
Minimum	7.2	1.8	8.6	1.3	66.7	1.5
Maximum	12.6	3.2	15.7	4.2	73.9	3.2
Average	10.9	2.4	12.4	2.7	69.8	1.8
Oats:						
Minimum	8.9	2	8	1.5	53.5	3.4
Maximum	13.5	4	14.4	12.9	66.9	5.8
Average	11	3	11.8	9.5	59.7	5
Rye:						
Minimum	8.7	1.8	9.5	1.4	71.2	1.4
Maximum	13.2	1.9	12.1	2.1	73.9	2.1
Average	11.6	1.9	10.6	1.7	72.5	1.7
Wheat, all varieties:						
Minimum	7.1	.8	8.1	.4	64.8	1.3
Maximum	14	3.6	17.2	3.1	77.7	3.9
Average	10.5	1.8	11.9	1.8	71.9	2.1
Sunflower seed (whole), average	8.6	2.6	16.3	29.9	21.4	21.2
Cotton seed (whole, with hulls):						
Minimum	7	2.9	14.5	20.3	17.3	18.9
Maximum	17.5	4.5	21.7	28.7	29.1	21.6
Average	10.3	3.5	18.4	23.2	24.7	19.9
Peanut kernels (without hulls), average	7.5	2.4	27.9	7	15.6	39.6
Horse bean	11.3	3.8	26.6	7.2	50.1	1
Soja bean, average	10.8	4.7	34	4.8	28.8	16.9
Cowpea, average	14.8	3.2	20.8	4.1	55.7	1.4
MILL PRODUCTS.						
Corn meal:						
Minimum	8	.9	7.1	.5	60.4	2
Maximum	27.4	4.1	13.9	3.1	74	5.1
Average	15	1.4	9.2	1.9	68.7	3.8
Corn and cob meal:						
Minimum	9.5	1.2	5.8	4.7	56.8	2.5
Maximum	26.3	1.9	12.2	9.4	69.7	4.7
Average	15.1	1.5	8.5	6.6	64.8	3.5
Oatmeal, average	7.9	2	14.7	.9	67.4	7.1
Barley meal, average	11.9	2.6	10.5	6.5	66.3	2.2
Pea meal, average	10.5	2.6	20.2	14.4	51.1	1.2
WASTE PRODUCTS.						
Oat feed, average	7.7	3.7	16	6.1	59.4	7.1
Barley screenings, average	12.2	3.6	12.3	7.3	61.8	2.8
Malt sprouts, average	10.2	5.7	23.2	10.7	48.5	1.7

a Lucern.

Composition of feeding stuffs—Continued.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
WASTE PRODUCTS—continued.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Brewers' grains, wet, average	75.7	1	5.4	3.8	12.5	1.6
Brewers' grains, dried, average	8.2	3.6	19.9	11	51.7	5.6
Rye bran, average	11.6	3.6	14.7	3.5	63.8	2.8
Wheat bran, all analyses:						
Minimum	7.4	2.5	12.1	2.4	45.5	1.5
Maximum	15.8	7.8	18.9	15.5	63.2	7
Average	11.9	5.8	15.4	9	53.9	4
Wheat middlings:						
Minimum	9.2	1.4	10.1	1.3	53	2.1
Maximum	16	6.3	20	12.7	70.9	5.9
Average	12.1	3.3	15.6	4.6	60.4	4
Wheat shorts:						
Minimum	4.1	2	11.1	6	50	2.5
Maximum	15.5	6.2	19.4	10.5	67	6.1
Average	11.8	4.6	14.9	7.4	56.8	4.5
Wheat screenings, average	11.6	2.9	12.5	4.9	65.1	3
Rice bran, average	9.7	10	12.1	9.5	49.9	8.8
Rice hulls, average	8.2	13.2	3.6	35.7	38.6	.7
Rice polish, average	10	6.7	11.7	6.3	58	7.3
Buckwheat middlings, average	13.2	4.8	28.9	4.1	41.9	7.1
Cotton-seed meal:						
Minimum	5.8	5.7	23.3	1.3	15.7	8.8
Maximum	18.5	8.8	50.8	10.1	38.7	18
Average	8.2	7.2	42.3	5.6	23.6	13.1
Cotton-seed hulls:						
Minimum	9.2	1.8	2.2	37.9	12.4	.6
Maximum	16.7	4.4	5.4	67	41.8	5.4
Average	11.1	2.8	4.2	46.3	33.4	2.2
Linseed meal, old process:						
Minimum	5.6	4.6	27.7	4.7	28.4	5.2
Maximum	12.4	8.2	38.2	12.9	41.9	11.6
Average	9.2	5.7	32.9	8.9	35.4	7.9
Linseed meal, new process:						
Minimum	6	5	27.1	7.6	35.2	1.3
Maximum	13.4	6.9	38.4	4	48	4.4
Average	10.1	5.8	33.2	9.5	38.4	3
Peanut meal:						
Minimum	6.6	3.7	37.5	2.5	28.5	5.8
Maximum	15.4	5.5	52.4	7.4	30.8	17.5
Average	10.7	4.9	47.6	5.1	23.7	8
Peanut hulls, average	9	3.4	6.6	64.3	15.1	1.6
Hominy chops:						
Minimum	8.1	1.9	7.9	2.5	61	4.5
Maximum	13.5	3.1	11.2	6.7	71.1	11.2
Average	11.1	2.5	9.8	3.8	64.5	8.3
REFUSE FROM CORNSTARCH FACTORIES.						
Corn germ:						
Minimum	9.4	1.9	9.7	1.9	61.9	5.2
Maximum	13	7.4	9.9	5.8	67.4	11.2
Average	10.7	4	9.8	4.1	64	7.4
Corn-germ meal, average	8.1	1.3	11.1	9.9	62.5	7.1
Gluten meal:						
Minimum	6.2	.5	21.3	.3	34	3.4
Maximum	12.3	2	39.2	7.8	58.5	20
Average	8.8	.8	29.7	2.2	49.8	8.7
Recent analyses—						
Minimum	6.2	.5	21.4	.6	34	6.6
Maximum	11.1	2	39.3	7.8	58.4	20
Average	8.2	.9	29.3	3.3	46.5	11.8
Chicago, average	10.1	1.1	30.1	1.6	48.7	8.4
Buffalo, average	8.2	.8	23.3	6.1	50.4	11.2
Cream gluten, average	8.1	.7	36.1	1.3	39	14.8
Gluten feed:						
Minimum	6.3	.7	19.5	1.5	44.5	7
Maximum	9	1.8	28.3	8.2	58	12.6
Average	7.8	1.1	24	5.3	51.2	10.6
Chicago maize feed, average	9.1	.9	22.8	7.6	52.7	6.9
Glucose feed and glucose refuse, average	6.5	1.1	20.7	4.5	56.8	10.4
Dried starch feed and sugar feed, average	10.9	.9	19.7	4.7	54.8	9
Starch feed, wet, average	65.4	.3	6.1	3.1	22	3.1

DIGESTIBILITY OF FEEDING STUFFS.

The preceding tables give the total amounts of nutrients found by analysis in different feeding stuffs. But only a portion of these amounts is of direct use to the animal, i. e., only that digested. The rest passes through the animal and is excreted as manure. The amounts of the different food constituents of feeding stuffs digested have been determined by careful experiments on different classes of animals. The results thus obtained in American experiments have been used in calculating the amounts of digestible protein, fat, and carbohydrates contained in 100 pounds of different feeding stuffs shown in the table below. These are the figures which must be consulted in determining the food value of a given material and in selecting feeding stuffs for making up a ration.

The last column of the table, headed "fuel value," indicates the value of the food for producing heat for the body and energy for the work. It is stated in calories, a calorie being the amount of heat required to raise the temperature of a pound of water 4° F.

Dry matter and digestible food ingredients in 100 pounds of feeding stuffs.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Green fodder:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Corn fodder *a* (average of all varieties)	20.7	1.10	12.08	0.37	26,076
Rye fodder	23.4	2.05	14.11	.44	31,914
Oat fodder	37.8	2.69	22.66	1.04	51,624
Redtop, in bloom	34.7	2.06	21.24	.58	45,785
Orchard grass, in bloom	27	1.91	15.91	.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	.42	34,755
Timothy, *b* at different stages	38.4	2.28	23.71	.77	51,591
Kentucky blue grass	34.9	3.01	19.83	.83	45,985
Hungarian grass	28.9	1.92	15.63	.36	34,162
Red clover, at different stages	29.2	3.07	14.82	.69	36,187
Crimson clover	19.3	2.16	9.31	.44	23,191
Alfalfa, *c* at different stages	28.2	3.89	11.20	.41	29,798
Cowpea	16.4	1.68	8.08	.25	19,209
Soja bean	28.5	2.79	11.82	.63	29,833
Corn silage	20.9	.56	11.79	.65	25,714
Corn fodder, *a* field cured	57.8	2.48	33.38	1.15	71,554
Corn stover, field cured	59.5	1.98	33.16	.57	67,766
Hay from—					
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	.95	100,078
Timothy, *b* all analysis	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.33	1.95	86,516
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Rowen (mixed)	83.4	7.19	41.20	1.43	96,040
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	6.58	35.35	1.66	84,995
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95,877
Alfalfa *c*	91.6	10.58	37.33	1.38	94,936
Cowpea	89.3	10.79	38.40	1.51	97,865
Soja bean	88.7	10.78	38.72	1.54	98,568
Wheat straw	90.4	.80	37.94	.46	73,998
Rye straw	92.9	.74	42.71	.35	82,294
Oat straw	90.8	1.58	41.63	.74	83,493
Soja-bean straw	89.9	2.30	39.98	1.03	82,987
Roots and tubers:					
Potatoes	21.1	1.27	15.59	....	31,360
Beets	13	1.21	8.84	.05	18,904
Mangel-wurzels	9.1	1.03	5.65	.11	12,888
Turnips	9.5	.81	6.46	.11	13,986
Ruta-bagas	11.4	.88	7.74	.11	16,497
Carrots	11.4	.81	7.83	.22	16,999
Grains and other seeds:					
Corn (average of dent and flint)	89.1	7.92	66.69	4.28	156,836
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat (all varieties)	89.5	10.23	69.21	1.68	154,848
Cotton seed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85	7.01	65.20	3.25	148,026
Corn and cob meal	84.9	6.46	56.28	2.87	128,808
Oatmeal	92.1	11.53	52.06	5.93	143,302

a Corn fodder is entire plant, usually sown thick. *b* Herd's grass of New England and New York. *c* Lucern.

Dry matter and digestible food ingredients in 100 pounds of feeding stuffs—Continued.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Mill products—Continued.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Barley meal	88.1	7.36	62.88	1.96	138,818
Ground corn and oats, equal parts	88.1	7.39	61.20	3.72	143,276
Pea meal	89.5	16.77	51.78	.65	130,246
Waste products:					
Gluten feed	92.2	20.40	43.75	8.59	155,569
Gluten meal	91.2	25.49	42.32	10.38	169,930
Hominy chops	88.9	7.45	55.24	6.81	145,342
Malt sprouts	89.8	18.72	43.50	1.16	120,624
Brewers' grains (wet)	24.3	4	9.37	1.38	30,692
Brewers' grains (dried)	91.1	14.73	36.60	4.82	115,814
Rye bran	88.4	11.45	50.28	1.96	123,089
Wheat bran, all analyses	88.5	12.01	41.23	2.87	111,138
Wheat middlings	84	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Buckwheat middlings	86.8	17.34	26.58	4.54	100,850
Cotton-seed meal	91.8	37.01	16.52	12.58	152,653
Cotton-seed hulls	88.9	.42	30.95	1.69	65,480
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	89.8	27.89	36.36	2.73	131,026
Peanut meal	89.3	42.94	22.82	6.86	151,263
Milk and its by-products:					
Whole milk	12.8	3.48	4.77	3.70	30,866
Skim milk—					
Cream raised by setting	9.6	3.13	4.69	.83	18,048
Cream raised by separator	9.4	2.94	5.24	.29	16,439
Buttermilk	9.9	3.87	4	1.06	37,685
Whey	6.6	.84	4.74	.31	11,687

FEEDING STANDARDS.

Attempts have been made to ascertain the food requirements of various kinds of farm animals under different conditions. From the results of experiments feeding standards have been worked out which show the amounts of digestible protein, fat, and carbohydrates supposed to be best adapted to different animals when kept for different purposes. The feeding standards of Wolff, a German, have been most widely used. They are as follows:

Wolff's feeding standards.

A.—PER DAY AND PER 1,000 POUNDS LIVE WEIGHT.

Kind of animal.	Total organic matter.	Digestible food materials.			Fuel value.
		Protein.	Carbohydrates.	Fat.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Oxen at rest in stall	17.5	0.7	8	0.15	16,815
Wool sheep, coarser breeds	20	1.2	10.3	.20	22,235
Wool sheep, finer breeds	22.5	1.5	11.4	.25	25,050
Oxen moderately worked	24	1.6	11.3	.30	24,260
Oxen heavily worked	26	2.4	13.2	.50	31,126
Horses moderately worked	22.5	1.8	11.2	.60	26,712
Horses heavily worked	25.5	2.8	13.4	.80	33,508
Milch cows	24	2.5	12.5	.40	29,590
Fattening steers:					
First period	27	2.5	15	.50	34,660
Second period	26	3	14.8	.70	36,062
Third period	25	2.7	14.8	.60	35,082
Fattening sheep:					
First period	26	3	15.2	.50	35,962
Second period	25	3.5	14.4	.60	35,826
Fattening swine:					
First period	36	5	27.5		60,450
Second period	31	4	24		52,080
Third period	23.5	2.7	17.5		37,570

Wolff's feeding standards—Continued.

B.—PER DAY AND PER HEAD.

Kind of animal.	Average live weight per head.	Total organic matter.	Digestible food materials. Protein.	Carbohydrates.	Fat.	Fuel value.
Growing cattle:						
Age—	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
2 to 3 months	150	3.3	0.6	2.1	0.30	5,116
3 to 6 months	300	7	1	4.1	.30	10,750
6 to 12 months	500	12	1.3	6.8	.30	16,332
12 to 18 months	700	16.8	1.4	9.1	.28	20,712
18 to 24 months	850	20.4	1.4	10.3	.26	22,859
Growing sheep:						
Age—						
5 to 6 months	56	1.6	.18	.87	.045	2,143
6 to 8 months	67	1.7	.17	.85	.040	2,066
8 to 11 months	75	1.7	.16	.85	.037	2,035
11 to 15 months	82	1.8	.14	.89	.032	2,051
15 to 20 months	85	1.9	.12	.88	.025	1,966
Growing fat swine:						
Age—						
2 to 3 months	50	2.1	.38	1.50		3,496
3 to 5 months	100	3.4	.50	2.50		5,580
5 to 6 months	125	3.9	.54	2.96		6,510
6 to 8 months	170	4.6	.58	3.47		7,533
8 to 12 months	250	5.2	.62	4.05		8,686

CALCULATION OF RATIONS.

In order to explain the use of the preceding tables let us calculate the daily ration for a cow, assuming that the farmer has on hand clover hay, corn silage, corn meal, and wheat bran. Wolff's standard for a cow of 1,000 pounds calls for 2.5 pounds of protein, 12.5 pounds of carbohydrates, and 0.4 pound of fat, which would furnish 29,590 calories of heat. From the table showing the amounts of digestible nutrients we find that 100 pounds of clover hay furnishes 84.7 pounds of dry matter, 6.58 pounds of protein, 35.35 pounds of carbohydrates, and 1.66 pounds of fat, equivalent to a fuel value of 84,995 calories. Twelve pounds would have 10.16 pounds of dry matter, 0.79 pound of protein, 4.24 pounds of carbohydrates, and 0.20 pound of fat, giving a fuel value of 10,199 calories. In the same way the amounts furnished by 20 pounds of corn silage, 4 pounds of corn meal, and 4 pounds of wheat bran are found. The result would be the following table:

Method of calculating ration for dairy cow.

Ration.	Total dry matter.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
12 pounds of clover hay	10.16	0.79	4.24	0.20	10,199
20 pounds of corn silage	4.18	.11	2.36	.13	5,143
4 pounds of corn meal	3.40	.28	2.61	.13	5,921
4 pounds of wheat bran	3.54	.48	1.65	.11	4,446
Total	21.28	1.66	10.86	.57	25,709
Wolff's standard	24	2.50	12.50	.40	29,590

This ration is below the standard, especially in protein. To furnish the protein needed, without increasing the other nutrients too much, a feeding stuff quite rich in protein is needed. The addition of 4 pounds of gluten feed would make the ration contain:

Completed ration for dairy cow.

Ration.	Total dry matter.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
12 pounds clover hay, 20 pounds corn silage, 4 pounds corn meal, and 4 pounds wheat bran	21.28	1.66	10.86	0.57	25,709
4 pounds gluten feed	3.69	.82	1.75	.34	6,223
Total	24.97	2.48	12.61	.91	31,932

This ration, it will be seen, contains somewhat more carbohydrates and fat than the standard calls for, but is close enough to the standard for practical purposes. The calculation may be considerably simplified by considering only the protein and the fuel value without impairing accuracy. For example, suppose the farmer feeds his cows dry corn fodder (not stover), good timothy hay (herd's grass), and a grain mixture composed of equal parts of corn meal, wheat bran, and gluten meal. A ration might be made from these as follows:

Ration per cow daily.

Ration.	Dry matter.	Protein.	Fuel value.
	Pounds.	*Pounds.*	*Calories.*
10 pounds timothy hay	8.68	0.30	9,273
10 pounds dry corn fodder	5.78	.25	7,155
4 pounds corn meal	3.40	.28	5,921
4 pounds wheat bran	3.54	.48	4,446
4 pounds gluten meal	3.62	1.02	6,797
Total	25.02	2.33	33,592

This ration is higher than the standard in fuel value, owing to richness of the materials in carbohydrates and fat, and slightly lower in protein. The substitution of 1 pound of new-process linseed meal in place of 1 pound of the corn meal would give 0.21 pound more protein, which would make the ration contain 2.54 pounds of protein.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
GREEN FODDERS	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Corn fodder	78.61	4.84	0.41	0.15	0.33
Sorghum fodder	82.19		.23	.09	.23
Rye fodder	62.11		.33	.15	.73
Oat fodder	83.36	1.31	.49	.13	.38
Common millet	62.58		.61	.19	41
Japanese millet	71.05		.53	.20	.34
Hungarian grass (*Setaria*)	74.31		.39	.16	.55
Orchard grass (*Dactylis glomerata*) *a*	73.14	2.09	.43	.16	.76
Timothy grass (*Phleum pratense*) *a*	66.90	2.15	.48	.26	.76
Perennial rye grass (*Lolium perenne*) *a*	75.20	2.60	.47	.28	1.10
Italian rye grass (*Lolium italicum*) *a*	74.85	2.84	.54	.29	1.14
Mixed pasture grasses	63.12	3.27	.91	.23	.75
Red clover (*Trifolium pratense*)	80		.53	.13	.46
White clover (*Trifolium repens*)	81		.56	.20	.24
Alsike clover (*Trifolium hybridum*)	81.80	1.47	.44	.11	.20
Scarlet clover (*Trifolium incarnatum*)	82.50		.43	.13	.49
Alfalfa (*Medicago sativa*)	75.30	2.25	.72	.13	.56
Cowpea	78.81	1.47	.27	.10	.31
Serradella (*Ornithopus sativus*)	82.59	1.82	.41	.14	.42
Soja bean (*Soja hispida*)	73.20		.29	.15	.53
Horse bean (*Vicia faba*)	74.71		.68	.33	1.37
White lupine (*Lupinus albus*)	85.35		.44	.35	1.73
Yellow lupine (*Lupinus luteus*) *a*	83.15	.96	.51	.11	.15
Flat pea (*Lathyrus sylvestris*) *a*	71.60	1.93	1.13	.18	.58
Common vetch (*Vicia sativa*) *a*	84.50	1.94	.59	1.19	.70
Prickly comfrey (*Symphytum asperrimum*)	84.36	2.45	.42	.11	.75
Corn silage	77.95		.28	.11	.37
Apple pomace silage *a*	75	1.05	.32	.15	.40
HAY AND DRY COARSE FODDERS.					
Corn fodder (with ears)	7.85	4.91	1.76	.54	.89
Corn stover (without ears)	9.12	3.74	1.04	.29	1.40
Teosinte (*Euchlæna luxurians*)	6.06	6.53	1.46	.55	3.70
Common millet	9.75		1.28	.49	1.69
Japanese millet	10.45	5.80	1.11	.40	1.22
Hungarian grass	7.69	6.18	1.20	.35	1.30
Hay of mixed grasses	11.99	6.34	1.41	.27	1.55
Rowen of mixed grasses	18.52	9.57	1.61	.43	1.49
Redtop (*Agrostis vulgaris*)	7.71	4.59	1.15	.36	1.02

a Dietrich and König: Zusamensetzung und Verdaulichkeit der Futtermittel.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS, ETC.—Cont'd.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
HAY AND DRY COARSE FODDERS—continued.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Timothy	7.52	4.93	1.26	.53	.90
Orchard grass	8.84	6.42	1.31	.41	1.88
Kentucky blue grass (*Poa pratensis*)	10.35	4.16	1.19	.40	1.57
Meadow fescue (*Festuca pratensis*)	8.89	8.08	.99	.40	2.10
Tall meadow oat grass (*Arrhenatherum avenaceum*)	15.35	4.92	1.16	.32	1.72
Meadow foxtail (*Alopecurus pratensis*)	15.35	5.24	1.54	.44	1.99
Perennial rye grass	9.13	6.79	1.23	.56	1.55
Italian rye grass	8.71	....	1.19	.56	1.27
Japanese buckwheat	5.72	....	1.63	.85	3.32
Red clover	11.33	6.93	2.07	.38	2.20
Mammoth red clover (*Trifolium medium*)	11.41	8.72	2.23	.55	1.22
White clover	....	....	2.75	.52	1.81
Scarlet clover *a*	18.30	7.70	2.05	.40	1.31
Alsike clover	9.94	11.11	2.34	.67	2.23
Alfalfa	6.55	7.07	2.19	.51	1.68
Blue melilot (*Melilotus cœruleus*)	8.22	13.65	1.92	.54	2.80
Bokhara clover (*Melilotus alba*)	7.43	7.70	1.98	.56	1.83
Sainfoin (*Onobrychis sativa*)	12.17	7.55	2.63	.76	2.02
Sulla (*Hedysarum coronarium*)	9.39	....	2.46	.45	2.09
Lotus villosus	11.52	8.23	2.10	.59	1.81
Soja bean (whole plant)	6.30	6.47	2.32	.67	1.08
Soja bean (straw)	13	....	1.75	.40	1.32
Cowpea (whole plant)	10.95	8.40	1.95	.52	1.47
Serradella	7.39	10.60	2.70	.78	.65
Oxeye daisy (*Chrysanthemum leucanthemum*)	9.65	6.37	.28	.44	1.25
Dry carrot tops	9.76	12.52	3.13	.61	4.88
Barley straw	11.44	5.30	1.31	.30	2.09
Barley chaff	13.08	....	1.01	.27	.99
Wheat straw	12.56	3.81	.59	.12	.51
Wheat chaff	8.05	7.18	.79	.70	.42
Rye straw	7.61	3.25	.46	.28	.79
Oat straw	9.09	4.76	.62	.20	1.24
Buckwheat hulls	11.90	....	.49	.07	.52
ROOTS, BULBS, TUBERS, ETC.					
Potatoes	79.75	.99	.21	.07	.29
Red beets	87.73	1.13	.24	.09	.44
Yellow fodder beets	90.60	.95	.19	.09	.46
Sugar beets	86.95	1.04	.22	.10	.48
Mangel-wurzels	87.29	1.22	.19	.09	.38
Turnips	89.49	1.01	.18	.10	.39
Ruta-bagas	89.13	1.06	.19	.12	.49
Carrots	89.79	9.22	.15	.09	.51
GRAINS AND OTHER SEEDS.					
Corn kernels	10.88	1.53	1.82	.70	.40
Sorghum seed	14	....	1.48	.81	.42
Barley *a*	14.30	2.48	1.51	.79	.48
Oats	18.17	2.98	2.06	.82	.62
Wheat (spring)	14.35	1.57	2.36	.70	.39
Wheat (winter)	14.75	....	2.36	.89	.61
Rye	14.90	....	1.76	.82	.54
Common millet	12.68	....	2.04	.85	.36
Japanese millet	13.68	....	1.73	.69	.38
Rice	12.60	.82	1.08	.18	.09
Buckwheat	14.10	....	1.44	.44	.21
Soja beans	18.33	4.99	5.30	1.87	1.99
MILL PRODUCTS.					
Corn meal	12.95	1.41	1.58	.63	.40
Corn and cob meal	8.96	....	1.41	.57	.47
Ground oats	11.17	3.37	1.86	.77	.59
Ground barley	13.43	2.06	1.55	.66	.34
Rye flour	14.20	....	1.68	.85	.65
Wheat flour	9.83	1.22	2.21	.57	.54
Pea meal	8.85	2.68	3.08	.82	.99
BY-PRODUCTS AND WASTE MATERIALS.					
Corn cobs	12.09	.82	.50	.06	.60
Hominy feed	8.93	2.21	1.63	.98	.49
Gluten meal	8.59	.73	5.03	.33	.05
Starch feed (glucose refuse)	8.10	....	2.62	.29	.15
Malt sprouts	18.38	12.48	3.55	1.43	1.63
Brewers' grains (dry)	9.14	3.92	3.62	1.03	.09
Brewers' grains (wet)	75.01	....	.89	.31	.05
Rye bran	12.50	4.60	2.32	2.28	1.40

FERTILIZING CONSTITUENTS OF FEEDING STUFFS, ETC.—Cont'd.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
BY-PRODUCTS AND WASTE MATERIALS—continued.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Rye middlings *a*	12.54	3.52	1.84	1.26	.81
Wheat bran	11.74	6.25	2.67	2.89	1.61
Wheat middlings	9.18	2.30	2.63	.95	.63
Rice bran	10.20	12.94	.71	.29	.24
Rice polish	10.30	9	1.97	2.67	.71
Buckwheat middlings *a*	14.70	1.40	1.38	.68	.34
Cottonseed meal	9.90	6.82	6.64	2.68	1.79
Cottonseed hulls	10.63	2.61	.75	.18	1.08
Linseed meal (old process)	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process)	7.77	5.37	5.78	1.83	1.39
Apple pomace	80.50	.27	23	.02	.13
VEGETABLES.					
Artichokes	81.50	.99	.36	.17	.48
Asparagus stems	93.96	.67	.29	.08	.29
Beans, adzuki	15.86	3.53	3.29	.95	1.51
Beets, red	88.47	1.04	.24	*b*.09	*b*.44
Cabbages	90.52	1.40	.38	*b*.11	*b*.43
Carrots	88.59	1.02	.16	.09	.51
Cauliflower	90.82	.81	.13	.16	.36
Chorogi tubers	78.90	1.09	1.92	.19	.64
Cucumbers	95.99	.46	.16	.12	.24
Horse-radish root	76.68	1.87	.36	.07	1.16
Kohl-rabi	91.08	1.27	.48	.27	.43
Lettuce, whole plant	93.68	1.61	.23	*b*.07	*b*.37
Onions	87.55	.57	.14	.04	.10
Parsnips	80.34	1.03	.22	.19	.62
Peas:					
Garden	12.62	3.11	3.58	.84	1.01
Small (*Lathyrus sativus*), whole plant	5.80	5.94	2.50	.59	1.99
Pumpkins, whole fruit	92.27	.63	*b*.11	*b*.16	*b*.09
Rhubarb:					
Roots	74.35	2.28	.55	.06	.53
Stems and leaves	91.67	1.72	.13	.02	.36
Ruta-bagas	88.61	1.15	.19	.12	.49
Spinach	92.42	1.94	.49	.16	.27
Sweet corn:					
Cobs	80.10	.59	.21	.05	.22
Husks	86.19	.56	.18	.07	.22
Kernels	82.14	.56	.46	.07	.24
Stalks	80.86	1.25	.28	.14	.41
Sweet potatoes:					
Tubers	72.96	.95	.23	.10	.50
Vines	83.06	2.45	.42	.07	.73
Tomatoes:					
Fruits	93.64	.47	.16	.05	.27
Roots	73.31	11.72	.24	.06	.29
Vines	83.61	3	.32	.07	.50
Turnips	90.46	.80	.18	.10	.39
FRUITS AND NUTS.					
Apple leaves:					
Collected in May	72.36	2.33	.74	.25	.25
Collected in September	60.71	3.46	.89	.19	.39
Apples, fruit	85.30	.39	.13	.01	.19
Apple trees (young):					
Branches	83.60	.65	....	.04	.04
Roots	64.70	1.59	....	.11	.09
Trunks	51.70	1.17	....	.06	.06
Whole plant	60.83	....	.35	.05	.17
Apricots, fresh	85.16	.49	.19	.06	.29
Blackberries	88.91	.58	.15	.09	.20
Blueberries	82.69	.16	.14	.05	.05
Cherries, fruit	86.10	.58	.18	*a*.06	*a*.20
Cherry trees (young):					
Branches	79.50	.78	....	.05	.06
Roots	67.20	1.22	....	.08	.07
Trunks	53.20	.81	....	.04	.06
China berries	16.52	4.13	1.19	.43	2.33
Cranberries:					
Fruit	89.59	.18	....	.03	.09
Vines	....	2.45	....	.27	.32
Currants	86.02	.53	....	.11	.27
Grapes, fruit, fresh	83	.50	.16	.09	.27
Grapes, wood of vine	....	2.97	....	.42	.67
Lemons	83.83	.56	.15	.06	.27

a Dietrich and König. *b* Wolff.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS, ETC.—Cont'd.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
FRUITS AND NUTS—continued.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Nectarines	79	.50	.12	....	....
Olives:					
Fruit	58	1.42	.18	.12	.86
Leaves	42.40	2.51	.91	.26	.76
Wood of larger branches	14.50	.94	.88	.11	.18
Wood of small branches	18.75	.96	.89	.12	.20
Oranges:					
California	85.21	.43	.19	.05	.21
Florida	87.71	....	.12	.08	.48
Peaches:					
Fruit	87.85	.32	....	.05	.24
Wood of branches	58.26	1.93	.90	.22	.50
Pears, fruit	83.92	.54	.09	.03	.08
Pear trees (young):					
Branches	84	.76	....	.04	.08
Roots	66.70	1.40	....	.07	.11
Trunks	49.30	1.71	....	.07	.13
Plums	47.43	.54	.18	.02	.24
Prunes	77.38	.49	.16	.07	.31
Raspberries	81.82	.55	.15	.48	.35
Strawberries:					
Fruit	90.84	.60	.15	.11	.30
Vines	....	3.34	....	.48	.35
Chestnuts, native	40	1.62	1.18	.39	.63
Peanuts:					
Hulls	10	2.99	1.04	.14	.81
Kernels	10	2.21	4.01	.82	.88
Vines after blooming	10	12.36	....	.29	.90
Vines before blooming	30	7.45	....	.32	1.16
DAIRY PRODUCTS.					
Whole milk	87	.75	.53	.19	.18
Skim milk	90.25	.80	.56	.20	.19
Cream	74.05	.50	.40	.15	.13
Buttermilk	90.50	.70	.48	.17	.16
Whey	92.97	.60	.15	.14	.18
Butter	79.10	.15	.12	.04	.04
Cheese	33.25	2.10	3.93	.60	.12
WOODS.					
Ash, wood	10	.32	....	.012	.149
Chestnut:					
Bark	10	3.51	....	.114	.278
Wood	10	.16	....	.011	.029
Dogwood:					
Bark	10	9.87	....	.140	.341
Wood	10	.68	....	.057	.190
Hickory:					
Bark	10	3.97	....	.061	.141
Wood	10	.48	....	.058	.138
Magnolia:					
Bark	10	2.98	....	.095	.192
Wood	10	.36	....	.032	.071
Maple, bark	10	9.49	....	.421	1.197
Oak:					
Leaves, mixed	....	4.70	....	....	....
Post, bark	10	12.10	....	.116	.249
Post, wood	10	.77	....	.070	.169
Red, bark	10	6.29	....	.103	.179
Red, wood	10	.57	....	.060	.140
White, bark	10	5.95	....	.074	.125
White, wood	10	.26	....	.025	.106
Pine:					
Burr	....	1.09	....	....	....
Georgia, bark	10	.37	....	.013	.024
Georgia, wood	10	.33	....	.012	.050
Old field, bark	10	1.94	....	.095	.077
Old field, wood	10	.18	....	.007	.008
Straw, mixed	....	1.65	....	....	....
Yellow, wood	10	.23	....	.010	.045
Black, wood	10	.21	....	.009	.030
Sycamore, wood	10	.99	....	.121	.230

Table giving the number of grains in 1 pound of seed of the principal grasses and forage plants, the amount to sow per acre of seed of standard purity, the amount to sow of pure and germinating seed, the weight per bushel, the cost of seed per acre, and the weight of 10,000,000 seeds, which is the standard amount per acre in composing mixtures.

[Columns 1, 2, 3, and 4 are compiled from The Best Forage Plants, by Stebler & Schroeter. The figures in column 5 are obtained by multiplying the amount of standard quality of seed required (column 2) by the retail price per pound quoted in New York catalogues. The weight of 10,000,000 grains (column 6) is obtained by dividing this quantity by the number of seeds in 1 pound (column 1).]

Name.	(1) Number of grains in 1 pound of pure seed.	(2) Amount to sow per acre, in pounds, standard quality.	(3) Amount to sow per acre, in pounds, of pure germinating seed.	(4) Weight per bushel.	(5) Cost of seed per acre.	(6) Weight of 10,000,000 grains.	Remarks.
				Pounds.		*Pounds.*	
Redtop (*Agrostis alba*)	603,000	9.7	7	8–32	$1.94	16.58	Requires moist climate or damp soil. Best propagated by transplanting small turf cuttings in autumn. Valuable for late pasturage or lawns in the New England and Middle States. Use 5 to 10 per cent in mixtures.
Reed canary grass (*Phalaris arundinacea*).	660,000	21	12	44–48	9.45	15.15	Adapted to stiff, wet lands and flooded fields. Requires moisture. Valuable hay when cut young, and well suited for binding loose banks near running water or for forming a firm sod on marshy ground.
Smooth-stalked meadow grass (*Poa pratensis*).	2,400,000	17.5	8.4	....	3.15	4.17	Grows best on soils which are strongly calcareous. Well adapted for pasture, and makes a good bottom grass for meadows. An excellent lawn grass.
Rough-stalked meadow grass (*Poa trivialis*).	3,000,000	19.5	8.75	11–17	8.77	3.33	Should be sown only on moist, fertile, and sheltered soils in mixtures.
Sheep's fescue (*Festuca ovina*).	680,000	28	12.6	10–15	7.00	14.85	Light, dry soils, especially those which are poor, shallow, and silicious. Valuable bottom grass and for sheep pastures. Sown only in mixtures.
Various-leafed fescue (*Festuca heterophylla*).	400,000	33.5	19.5	....	8.38	25	Best on moist, low lands containing humus, and sandy loams. Withstands drought; useful in pasture; unimportant for hay. Alone it makes no continuous turf.
Creeping fescue (*Festuca rubra*).	600,000	42.5	13	10–15	10.63	16.66	Valuable pasture or bottom grass. Withstands drought; endures both cold and shade. On poor land, especially moist sands and railway banks, serves to bind the soil. Product small.
Awnless brome grass (*Bromus inermis*).	137,000	44	35.6	....	13.20	72.99	Valuable for light soils, especially in regions subject to extremes of heat or long periods of drought. Used alone or in mixtures for permanent meadows and pastures.
Perennial rye grass (*Lolium perenne*).	336,800	55	38.5	18–30	6.60	29.7	Excellent and lasting pasture grass for heavy soils in moist, cool climates. On light, dry soils disappears after the second year. Rarely sown alone.
Italian rye grass (*Lolium italicum*).	285,000	48.5	32.4	12–24	6.79	35.1	Excellent for rich and rather moist lands. Regarded in Europe as one of the best for hay. Lasts only 2 or 3 years.
Orchard grass (*Dactylis glomerata*).	579,500	35	....	12–16	10.50	17.25	Grows well on any soil, excepting that which is very wet; withstands shade. Affords a great amount of aftermath. Valuable alike for hay and pasturage.
Meadow fescue (*Festuca pratensis*).	318,200	52	....	12–26	15.60	31.42	Thrives in either dry or wet soils. Valuable hay or pasture grass.
Meadow oat grass (*Arrhenatherum avenaceum*).	159,000	70	34.3	10	....	62.89	Thrives on moist, loamy sands, or light clays which are not too moist, and marls. Spring most favorable seed time. Valuable in the South for hay or winter pasture.

Table giving the number of grains in 1 pound of seed of the principal grasses and forage plants, etc.—Continued.

Name.	(1) Number of grains in 1 pound of pure seed.	(2) Amount to sow per acre, in pounds, standard quality.	(3) Amount to sow per acre, in pounds, of pure germinating seed.	(4) Weight per bushel.	(5) Cost of seed per acre.	(6) Weight of 10,000,000 grains.	Remarks.
				Pounds.		*Pounds.*	
Yellow oat-grass (*Trisetum flavescens*).	2, 045, 000	29	4. 64	5½	$36. 25	4. 89	Valuable for temporary or permanent pastures. Thrives on marly or calcareous soil, in all light land rich in humus.
Velvet grass (*Holcus lanatus*).	1, 304, 000	22	8. 8	6½	5. 50	7. 66	Sometimes sown on light, thin soils, unsuited for more valuable sorts. Rarely used excepting in mixtures.
Timothy (*Phleum pratense*)	1, 170, 500	16	14	48	1. 60	8. 54	Best known and most extensively cultivated for hay, sown alone or mixed with red top or clover. Succeeds best on moist loams or clays. On dry ground the yield is light.
Meadow foxtail (*Alopecurus pratensis*).	907, 000	23	6. 21	6	8. 05	11. 02	Endures cold. Likes strong soil, stiff loam or clay One of the best for land under irrigation. Very early. Two to four pounds in mixtures for permanent pastures.
Vernal grass (*Anthoxanthum odoratum*).	924, 000	30	7. 8	....	30. 00	10. 82	Grows on almost any kind of soil; sown only in mixtures, 1 to 2 pounds, with permanent pasture or meadow grasses.
Crested dog's tail (*Cynosurus cristatus*).	1, 127, 000	25	13. 5	20–32	....	8. 87	Especially adapted for loams, light clays, marls, and moist loamy sands. Moist climates are most suitable; withstands drought and thrives well in shade. Nutritive value high. Used in mixtures to form bottom grass either in pasture or hay.
Alsike clover (*Trifolium hybridum*).	707, 000	12. 3	9	94–100	2. 46	14. 14	Grows on strongest clay or peaty soils; peculiarly adapted to damp ground. Bears heavy frosts without injury. Sow in August or February.
Sainfoin (*Onobrychis sativa*).	22, 500	*a* 78	*a* 60. 84	40	11. 70	444. 44	Requires good and open subsoil, free from water. Sown alone, from end of March to beginning of May.
Red clover (*Trifolium pratense*).	279, 000	18	15. 84	64	2. 70	35. 84	Succeeds best in rich, loamy soil, on good clays, and on soils of an alluvial nature. A standard fodder plant.
White clover (*Trifolium repens*).	740, 000	10. 5	7. 5	63	3. 68	13. 51	Thrives on mellow land containing lime, and on all soils rich in humus. Resists drought. Generally used in mixtures for pastures or lawns.
Common kidney vetch (*Anthyllis vulneraria*).	154, 000	17. 5	15	60–64	6. 13	67. 15	Cultivated for grazing; on warm soils, if manured and of proper depth. Hardy; resists drought. Sheep, goats, and horned cattle eat it greedily.
Alfalfa or lucern (*Medicago sativa*).	209, 500	25	22	61–63	4. 00	48. 56	Grows well on any calcareous soil having a permeable subsoil. Especially adapted to the warm and dry regions of the West and Southwest. Requires irrigation.
Trefoil (*Medicago lupulina*)	328, 000	18	14. 75	64–66	5. 40	30. 48	Any soil containing sufficient moisture and lime is suitable. Most successful on clay marls. Cultivated only where the better kinds of clover can not be grown.
Bird's-foot trefoil (*Lotus corniculatus*).	375, 000	11	4. 67	60	....	26. 66	Thrives on dry or moist, sandy or clayey soils. Well suited to dry lands at high elevations, though poor.
Officinal goats' rue (*Galega officinalis*).	62, 000	22	6. 9	....	....	161. 29	Excellent fodder plant for warm, sheltered situations. Thrives only in deep soil, and when subsoil is not wet.

a Unshelled.

Table showing weight and cost of the seed of four mixtures, each designed to cover an acre upon the basis of 10,000,000 plants, compiled from Table 1.

	Seed.	Number of seeds.	Pounds.	Cost.
A.	Timothy	6,700,000	5.72	$0.57
	Alsike	1,650,000	2.33	.47
	White clover	1,650,000	2.23	.78
		10,000,000	10.28	1.82
B.	Timothy	5,000,000	4.27	.43
	Kentucky blue grass	1,000,000	.41	.07
	Orchard grass	700,000	1.21	.36
	Alsike	1,650,000	2.33	.47
	White clover	1,650,000	2.23	.78
		10,000,000	10.45	2.11
C.	Timothy	4,000,000	3.42	.34
	Kentucky blue grass	1,200,000	.50	.09
	Orchard grass	1,000,000	1.73	.52
	Meadow foxtail	500,000	.55	.19
	Alsike	1,650,000	2.33	.47
	White clover	1,650,000	2.23	.78
		10,000,000	10.76	2.39
D.	Red clover	2,790,000	10	1.50
	Alsike	2,121,000	3	.60
	Timothy	3,089,000	2.64	.26
	Redtop	2,000,000	3.31	.66
		10,000,000	18.95	3.02

FERTILIZERS.

Fertilizer.	Moisture.	Nitrogen.	Potash.	Phosphoric acid.			Lime.	Magnesia.	Sulphuric acid.	Chlorine.
				Soluble.	Reverted.	Total.				
COMMERCIAL FERTILIZERS.										
Ashes:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Limekiln	15.45		1.20			1.14	48.50	2.60		
Wood, leached	30.22		1.27			1.51	28.08	2.66	0.14	
Wood, unleached	12.50		5.25			1.70	34	3.40		
Bat guano	40.09	8.20	1.31	2.37	1.24	3.80				
Bone ash	7					35.89	44.89			
Bone black	4.60					28.28				
Dissolved				15.40	1.30	17				
Bone meal	7.50	4.05		.40	7.60	23.25				
Dissolved		2.60		13.53		17.60				
Free from fat		6.20				20.10				
From glue factory		1.70				29.90				
Castor pomace	9.50	5.50	1.10			1.75				
Cotton-hull ashes	7.80		22.75	1.25	6.50	8.85	9.60	10.75		
Cotton-seed meal:										
Decort	7.75	7.10	1.80			3.10				
Undecort		4.30	1.50			3.10				
Dried blood	12.50	10.52				1.91				
Dried fish	12.75	7.25		.55	2.60	8.25				
Eel grass (*Zostera marina*)	81.19	.35	.32			.07	.51	.32		
Gas lime	22.28						43.66	8.30	20.73	
Kainit	3.20		13.54				1.15	9.80	20.25	33.25
Kelp (*Laminaria saccharina* and *L. digitata*)	87.75	.20	.24			.06	.40	.20		
Meat scrap	12.09	10.44				2.07				
Mona Island guano	13.32	.76			7.55	21.88	37.49			
Muck	50	1.10	.15			.10				
Muriate of potash	2		51.48							48.80
Navassa phosphate	7.60					34.27	37.45			
Nitrate of potash	1.93	13.09	45.19							
Nitrate of soda	1.40	15.70								
Oyster-shell lime *a*	15		.05			.18	55	.35	.60	
Rockweed (*Fucus nodosus* and *F. vesiculosus*)	76.90	.31	.65			.10	.47	.33		
Seaweed ashes	1.47		.92			.30	6.06	4.37	2.98	6.60
South Carolina rock:										
Dissolved				11.60		15.20				
Ground	1.50			.27	.07	28.03	41.87	3.03		

a 18.5 carbonate.

FERTILIZERS—Continued.

Fertilizer.	Moisture.	Nitrogen.	Potash.	Phosphoric acid.			Lime.	Magnesia.	Sulphuric acid.	Chlorine.
				Soluble.	Reverted.	Total.				
COMMERCIAL FERTILIZERS—continued.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Sulphate of ammonia	1	20.50	......	......	......	......	......	......	60	......
Sulphate of potash (high grade)	2.54	......	33.40	......	......	......	......	......	45.72	......
Tankage	10	6.70	......	0.30	5.10	11.80	......	......	......	......
Thomas slag	1.45	......	......	......	3.06	23.49	48.66	3.42	......	......
Tobacco stalks	6.18	3.71	5.02	......	......	.65	2.22	.59	......	......
Tobacco stems	10	2.35	8.20	......	......	.70	4.20	.80	.65	0.65
FARM MANURES.										
Cattle excrement (solid, fresh)	......	0.29	0.10	......	......	0.17	......	......	......	......
Cattle urine (fresh)	......	.58	.49	......	......	......	......	......	......	......
Hen manure (fresh)	60	1.10	.56	......	......	.85	......	......	......	......
Horse excrement (solid)	......	.44	.35	......	......	.17	......	......	......	......
Horse urine (fresh)	......	1.55	1.50	......	......	......	......	......	......	......
Human excrement (solid)	77.20	1	.25	......	......	1.09	......	......	......	......
Human urine	95.90	.60	.20	......	......	.17	......	......	......	......
Pigeon manure (dry)	10	3.20	1	......	......	1.90	2.10	0.80	0.60	0.50
Poudrette (night soil)	50	.80	.30	......	......	1.40	.80	.60	.40	.08
Sheep excrement (solid, fresh)	......	.55	.15	......	......	.31	......	......	......	......
Sheep urine (fresh)	......	1.95	2.26	......	......	.01	......	......	......	......
Stable manure (mixed)	73.27	.50	.60	......	......	.30	......	......	......	......
Swine excrement (solid, fresh)	......	.60	.13	......	......	.41	......	......	......	......
Swine urine (fresh)	......	.43	.83	......	......	.07	......	......	......	......
Barnyard manure (average)	68.87	.49	.43	......	......	.32	......	......	......	......

Amount and value of manure produced by different farm animals.

[New York Cornell Experiment Station.]

Animals.	Per 1,000 pounds of live weight.			Value of manure per ton.
	Amount per day.	Value per day. *a*	Value per year. *a*	
	Pounds.	*Cents.*		
Sheep	34.1	7.2	$26.09	$3.30
Calves	67.8	6.2	24.45	2.18
Pigs	83.6	16.7	60.88	3.29
Cows	74.1	8	29.27	2.02
Horses	48.8	7.6	27.74	2.21

a Valuing nitrogen at 15 cents, phosphoric acid at 6 cents, and potash at 4½ cents per pound.

METHODS OF CONTROLLING INJURIOUS INSECTS, WITH FORMULAS FOR INSECTICIDES.

By C. L. MARLATT, *First Assistant Entomologist*, U. S. Department of Agriculture.

REMEDIES FOR IMPORTANT INSECTS.

ANGOUMOIS GRAIN MOTH (*Gelechia cereallella* Oliv.). Prompt thrashing of grain after harvesting; bisulphide of carbon in bins and granaries.

APPLE-LEAF SKELETONIZER (*Canarsia hammondi* Riley). Spraying with arsenicals (paris green and london purple) in June; hand picking of leaves with larvæ.

APPLE-ROOT PLANT-LOUSE (*Schizoneura lanigera* Hausm.). Kerosene emulsion under and above ground; scalding water poured freely about roots; bisulphide of carbon underground about roots; ashes around trunk.

APPLE-TREE BORER, FLAT-HEADED (*Chrysobothris femorata* Fab.). Painting trunk and larger branches in June with strong soap solution, washing soda, or mixture of whitewash and paris green; placing bars of soap in crotches of trees, to be washed down by rain.

ARMY WORM (*Leucania unipuncta* Haw.). Burning over fields in winter; ditching; paris green.

ASPARAGUS BEETLE (*Crioceris asparagi* Linn.). Prompt marketing of all canes; dusting with lime; arsenical mixtures (paris green and london purple).

BEAN WEEVIL (*Bruchus obtectus* Say). Treating with bisulphide of carbon in air-tight vessels.

BLISTER BEETLES (*Epicauta vittata* Fab., *E. cinerea* Lec., *E. pennsylvanica* DeG., *Macrobasis unicolor* Kb.). Arsenicals, 1 pound to 100 gallons of water.

BOLL WORM. (*See* Corn ear worm.)

BUFFALO GNAT (*Simulium pecuarum* Riley). Smudges; oil, grease, etc., applied to stock.

CABBAGE BUG, HARLEQUIN (*Murgantia histrionica* Hahn). Spring collecting from trap mustard; hand picking.

CABBAGE WORMS (*Pieris rapæ* Sch., *Plutella cruciferarum* Zell., *Plusia brassicæ* Riley). Pyrethrum; kerosene emulsion; paris green, dry, with flour or lime—1 part of the poison to 50 to 100 of the diluent.

CANKERWORM, SPRING (*Paleacrita vernata* Peck.). Arsenical mixtures in spray; trapping female moth in oil troughs or tar bands about trunk of trees.

CARPET BEETLE OR BUFFALO MOTH (*Anthrenus scrophulariæ* L.). Benzine; hot ironing of carpets over damp cloth; killing by steam.

CHINCH BUG (*Blissus leucopterus* Say). Burning wild grass land and all rubbish in early winter; kerosene emulsion; contagious disease; trap crops; ditching.

CLOTHES MOTH, SOUTHERN (*Tinea biselliella* Hum.). Airing and sunning; benzine; naphthaline; packing in paper bags.

COCKROACH, GERMAN; CROTON BUG (*Phyllodromia germanica* L.). Pyrethrum or buhach; bisulphide of carbon in tight rooms or compartments away from fire.

CODLING MOTH; APPLE WORM (*Carpocapsa pomonella* Linn.). Arsenicals; first application as soon as blossoms fall; second, one or two weeks later, just before the fruit turns down on the stem; trapping larvæ by applying bands to the tree; prompt destruction of infested fallen fruit.

COTTON WORM (*Aletia xylina* Say). Paris green dusted on as dry powder.

CORN ROOT-WORM (*Diabrotica longicornis* Say). Rotation of corn with oats or other crop.

CORN STALK-BORER, LARGER (*Diatræa saccharalis* F.). Plowing under or burning stubble.

CORN EAR WORM; BOLLWORM (*Heliothis armiger* Hbn.). Late fall plowing; poisoned baits; for cotton, planting corn as trap crop.

CURRANT WORM, IMPORTED (*Nematus ventricosus* Klug). Hellebore, 1 ounce to 2 gallons water, in spray.

CUCUMBER BEETLE, STRIPED (*Diabrotica vittata* Fab.). Protecting young plants with netting; arsenicals.

CUTWORMS (Agrotis, Leucania, Mamestra, Hadena, Nephelodes, etc.). Distribution of poisoned green bait; late fall plowing; burning waste tracts and rubbish.

ELM LEAF-BEETLE, IMPORTED (*Galeruca xanthomelæna* Schr.). Arsenicals, 1 pound to 100 gallons water.

FLEA-BEETLE, STRIPED (*Phyllotreta vittata* Fab.). Kerosene emulsion; arsenicals.

FLUTED SCALE (*Icerya purchasi* Mask.). Introduction of its ladybird enemy, *Vedalia cardinalis;* hydrocyanic-acid gas treatment; soap, 1 pound to 2 gallons hot water.

FRUIT BARK-BEETLE (*Scolytus rugulosus* Ratz.). Burning trap trees and infested trees at any time, but preferably in winter.

GRAIN WEEVILS (*Calandra granaria* Linn., *C. oryza* Linn.). Bisulphide of carbon in bins and granaries.

GRAPE PHYLLOXERA (*Phylloxera vastatrix* Planch.). Submersion; bisulphide of carbon, kerosene emulsion or resin compound about roots; use of resistant stocks.

GRAPEVINE LEAF-HOPPER (*Erythroneura vitis* Harr.). Spraying with kerosene emulsion in early morning; catching on tarred shield.

GYPSY MOTH (*Ocneria dispar* L.). Spraying with arsenicals; hand collecting of cocoons and eggs.

HESSIAN FLY (*Cecidomyia destructor* Say). Late planting; selection of wheat less subject to attack; rolling; pasturing to sheep; rotation of crops.

HOP PLANT-LOUSE (*Phorodon humuli* Schr.). Destroying all wild plum trees in vicinity; spraying others in fall or spring with strong kerosene emulsion; spraying vines with kerosene emulsion or fish-oil soap; destroying vines after hops are picked.

HORN FLY (*Hæmatobia serrata* R.-D.). Application of strong-smelling greases and oils to cattle, or lime or plaster to dung.

LOCUST, CALIFORNIA DEVASTATING (*Caloptenus devastator* Scudd.). Poisoned bait of bran, sugar, and arsenic.

LOCUST, LESSER MIGRATORY (*Caloptenus atlanis* Riley). (*See* Rocky Mountain locust.)

LOCUST, RED-LEGGED (*Caloptenus femur-rubrum* DeG.). (*See* Rocky Mountain locust.)

LOCUST, ROCKY MOUNTAIN (*Caloptenus spretus* Thos.). Catching with hopperdozers; ditching; burning; rolling; plowing under of eggs.

OX BOT (*Hypoderma lineata* Vill.). Strong-smelling fats and oils applied to cattle.
OYSTER-SHELL BARK-LOUSE (*Mytilaspis pomorum* Bouché). Kerosene emulsion; strong soap or alkali washes.
PEACH-TREE BORER (*Sannina exitiosa* Say). Cutting out the larvæ or scalding them with hot water in late autumn or early spring; painting trunk with arsenicals in thick whitewash; wrapping trunk with grass, paper, etc.
PEAR-TREE PSYLLA (*Psylla pyricola* Forst.). Kerosene emulsion: First, a winter application diluted seven times; second, in spring as soon as leaves are unfolded, diluted nine times.
PEAR-TREE SLUG (*Eriocampa cerasi* Peck.). Hellebore, 1 ounce to 2 gallons water in a spray; whale-oil soap, 12 pounds to 50 gallons water; arsenicals.
PEA WEEVIL (*Bruchus pisorum* Linn.). Keeping seed over to second year; bisulphide of carbon in tight vessels.
PLUM CURCULIO (*Conotrachelus nenuphar* Herbst). Arsenical spray: First, before the bloom appears or as soon as foliage starts; second, immediately after blossoms fall; third, a week or ten days after the last; collection of adults from trees by jarring.
POTATO BEETLE, COLORADO (*Doryphora 10-lineata* Say). Arsenicals, 1 pound to 100 gallons water.
PURPLE SCALE OF THE ORANGE (*Mytilaspis citricola* Pack.). Kerosene emulsion, applied immediately after appearance of new brood.
RICE WATER WEEVIL (*Lissorhoptrus simplex* Say). Draining.
ROSE CHAFER (*Macrodactylus subspinosus* Fab.). Planting spiræas, etc., as trap plants, and collecting beetles in special pans; arsenicals; kerosene emulsion.
SAN JOSE SCALE (*Aspidiotus perniciosus* Comst.). (*See ante*, pp. 272–276, for life history and remedies.)
SCREW WORM (*Compsomyia macellaria* Fab.). Prompt burning or burying of dead animals; smearing wounds with fish oil; washing with carbolic acid.
SQUASH BORER (*Melittia ceto* Westw.). Planting early summer squashes to be destroyed; late planting of main crop; destruction of all vines attacked as soon as crop can be gathered; collecting moths.
SQUASH BUG (*Anasa tristis* DeG.). Early burning of vines and all rubbish in fall; biweekly collection of eggs.
STRAWBERRY WEEVIL (*Anthonomus signatus* Say). Trap crops; protecting beds with cloth covering; using staminate varieties only as fertilizers and as few plants of the former as necessary; spraying with paris green.
SUGAR-CANE BORER (*Diatræa saccharalis* Fab.). Burning trash and laying down seed cane underground.
WEB WORM, FALL (*Hyphantria cunea* Dr.). Prompt removal and destruction of webs with larvæ; arsenical spraying.
WHEAT ISOSOMA (*Isosoma tritici* Riley). Burning stubble; rotation of crops.
WHEAT PLANT-LOUSE (*Siphonophora avenæ* Fab.). Rotation of crops.
WHITE GRUB; JUNE BEETLE (*Lachnosterna* spp.). Luring the beetles by lights over tubs into water with skim of kerosene. Against larvæ: Kerosene emulsion; liberal use of potash fertilizers; collecting after the plow.
WIREWORMS (*Drasterius elegans* Fab., *Melanotus fissilis* Say, and *Agriotes* spp.). Fall plowing; poisoned baits; rotation of crops.

INSECTICIDES.

(DIRECTIONS FOR THEIR PREPARATION AND USE.)

Paris green and london purple (*arsenicals*).—These are especially adapted to biting insects, including the majority of the injurious caterpillars, many beetles, and locusts, and are applied either in water or as powder. Paris green or london purple is used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for resistant foliage, as that of potato, and the greater dilutions for more sensitive foliage, as that of peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. Make the poison into a thin paint in a small quantity of water, and add powdered or quick lime equal to the amount of poison used, to remove the danger of scalding, and strain into the spray tank. Always use lime with london purple in any application to peach or plum; to the stronger foliage of apple and most shade trees paris green without lime may be safely applied at the rate of 1 pound to 150 gallons.

If it be desirable to combine in one application a fungicide with the insecticide, bordeaux mixture may be used instead of water as a diluent for the arsenical, the lime of this fungicide at once neutralizing the soluble arsenic.

Application in form of powder is valuable for any low-growing crop, and particularly cotton. In cotton fields the dry powder is usually dusted over plants from osnaburg bags attached to each end of a pole carried by a man on horseback. The

application is preferably made in the early morning or late evening, when the dew is on. From 1 to 4 pounds are required to the acre. Garden vegetables may be dusted from bags or with powder bellows, using a mixture of 1 ounce of poison with 6 pounds of flour or 10 of lime.

Poison bait.—This method is available for cutworms, wireworms, and local invasions of locusts. For locusts, take one part by weight of white arsenic, one of sugar, and six of bran, to which add water to make a wet mash. Place a teaspoonful of this at the base of each tree or vine, or apply just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet, and following up with another row behind the first. For cutworms and wireworms, small bunches of green plants, such as clover, dipped in a very strong arsenical solution, are distributed about in the infested fields, and protected from drying by covering with boards or stones. The bran-arsenic bait will also answer for cutworms.

Hellebore.—This insecticide is valuable for the currant worm and less so for other biting insects. Mix fresh white hellebore with water at the rate of 1 ounce of the former to 3 gallons of the latter. This poison can be safely applied to vegetables shortly before they are to be eaten.

Pyrethrum.—This insecticide is adapted for indoor use, or small patches, against all sorts of insects. Applied wet in a spray, it should be used at the rate of 1 ounce to 3 gallons of water, allowing it to stand twenty-four hours before applying. In the dry form it may be dusted about rooms and over plants, either pure or mixed with an equal bulk of air-slaked lime.

Soaps.—Any strong soap dissolved in water makes a good insecticide against soft-bodied insects, and may be used at the rate of half a pound to the gallon of water for plant-lice, pear slug, etc. Used at the rate of 1½ or 2 pounds to the gallon of water, it is one of the most satisfactory winter washes known against scale insects. The whale-oil soaps are very much the more effective, and spray more readily than solutions of other soaps.

Kerosene emulsion.—This is especially adapted to sucking insects, including plant bugs, plant-lice, scale insects, thrips, and plant-feeding mites. The kerosene and soap emulsion is prepared as follows:

Kerosene	gallons	2
Whale-oil soap (or 1 quart soft soap)	pound	½
Water	gallon	1

Dissolve the soap in boiling water, and add the hot solution, away from the fire, to the kerosene. Agitate violently for five minutes by pumping the liquid back upon itself with a force pump until the mixture assumes the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

In limestone or hard-water regions it is best to use the milk emulsion.

Kerosene	gallons	2
Milk (sour)	do	1

Heating is unnecessary; churn as in the former case for three to five minutes, or until a thick, buttery consistency results. Prepare the milk emulsion from time to time for immediate use.

For summer applications for most plant-lice and other soft-bodied insects, dilute these emulsions with 15 to 20 parts of water; for the red spider and other plant mites, the same, with 1 ounce of powdered sulphur per gallon; for scale insects, larger plant bugs, larvæ, and beetles, dilute with 7 to 9 parts water. For subterranean insects, such as root-lice, root maggots, white grubs, etc., use either kerosene emulsion (or resin wash), wetting the soil to a depth of 2 or 3 inches, and follow with copious waterings, unless in rainy season.

For winter applications to destroy scale insects, stronger mixtures may be used.

The resin wash.—This is valuable for scale insects in dry seasons:

Resin	pounds	20
Crude caustic soda (78 per cent)	do	5
Fish oil	pints	2½
Water to make (summer wash)	gallons	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used—3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil for one or two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, with-

out sediment, and should any appear in the stock mixture reheating should be resorted to.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale (*Aspidiotus perniciosus*), dilute one-third or one-half less for California and Florida. In colder climates it is not satisfactory.

The hydrocyanic-acid gas treatment.—This is especially valuable for scale insects. Tents of blue or brown drilling or 6-ounce duck, painted or oiled with linseed oil, to make as near air-tight as possible, are adjusted over small trees by hand or with poles, and over large trees with a tripod or derrick. Fused potassium cyanide (58 per cent purity), commercial sulphuric acid, and water are used in generating the gas, the proportions being 1 ounce by weight of the cyanide, slightly more than 1 fluid ounce of acid, and 3 fluid ounces of water to every 150 cubic feet of space inclosed. Place the generator (any glazed earthenware vessel of 1 or 2 gallons capacity) on the ground within the tent, and add the water, acid, and cyanide (in lumps) in the order named, the operator immediately withdrawing. Allow the tent to remain on the tree for one-half hour for large trees or fifteen minutes for small ones. The treatment is best made on cloudy days, early in the morning, late in the evening, or at night.

Bisulphide of carbon.—This substance is a cheap and effective remedy for insects affecting stored food and seeds, natural-history specimens, etc., and is one of the best means against insects affecting the roots of plants. It readily volatilizes and the vapor is highly inflammable and explosive, and should be carefully kept from fire. For root-lice of grape, apple, peach, etc., put one-half ounce of bisulphide into holes about plant, 10 to 16 inches deep, 1½ feet apart, and not closer to trunk than 1 foot, and close the holes. For root maggots, put spoonful into hole at base of plant and close immediately. For ant pests, pour an ounce of the liquid into each of several holes in the nest; close the opening with the foot or cover with a wet blanket for ten minutes and then explode the vapor at mouth of hole with torch. (For insects affecting stored grain, see p. 277.)

A CHEAP ORCHARD-SPRAYING OUTFIT.

Spraying to control various insect pests, particularly those of the orchard and garden, has reached so satisfactory and inexpensive a basis that it is recognized by every progressive farmer as a necessary feature of the year's operations, and in the case of the apple, pear, and plum crops, the omission of such treatment means serious loss. The consequent demand for spraying apparatus has been met by all the leading pump manufacturers of this country, and ready-fitted apparatus, consisting of pump, spray tank or barrel, and nozzle with hose, are on the market in numerous styles and at prices ranging from $20 upward. The cost of a spraying outfit for orchard work may, however, be considerably reduced by purchasing merely the pump and fixtures and mounting them at home on a strong barrel. An apparatus of this sort, representing a style that has proven very satisfactory in practical experience, is illustrated in the accompanying figure. It is merely a strong pump with an air-chamber to give a steady stream provided with two discharge hose pipes. One of these enters the barrel and keeps the water agitated and the poison thoroughly intermixed, and the other and longer one is the spraying hose and terminates in the nozzle. The spraying hose should be about 20 feet long and may be fastened to a light pole, preferably of bamboo, to assist in directing the spray. The nozzle should be capable of breaking the water up into a fine mist spray, so as to wet the plant completely with the least possible expenditure of liquid. The two more satisfactory nozzles are those of the Nixon and the Vermorel type. A suitable pump with nozzle and hose may be obtained of any pump manufacturer or hardware dealer at a cost of from $13 to $15. If one with brass fittings be secured it will also serve for the application of fungicides. The outfit outlined above may be mounted on a cart or wagon, the additional elevation secured in this way facilitating the spraying of trees, or for more extended operations, the pump may be mounted on a large water tank.

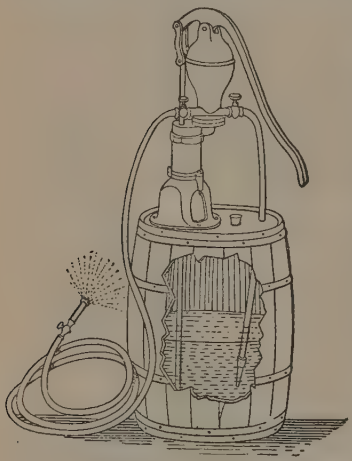

FIG. 140.—Orchard-spraying apparatus.

TREATMENT FOR FUNGOUS DISEASES OF PLANTS.

In the following table the plants affected are arranged alphabetically, and in columns opposite each name are given the number of times and methods of making the various treatments. Following the names of the fungicides are small numbers, which refer to the formulas for making them. The formulas follow the table:

Disease.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Remarks.
Almond or apricot shot-hole fungus.	Ammoniacal copper carbonate solution (1) when leaves unfold.	Same fungicide ten or twelve days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later, if necessary.	....	
Apple scab	Bordeaux mixture (2), 60-gallon formula, when fruit buds are unfolding.	Same fungicide when flower clusters are expanding.	Same fungicide when petals are falling.	Same fungicide when fruit is one-half inch in diameter, if wet weather prevails.	Same fungicide two weeks later, if wet weather prevails.	Paris green may be combined with the fungicide in a proportion of 4 ounces to every 50 gallons of the mixture to prevent ravages of codling moth.
Barley smut	Soak seed in cold water four hours.	Place in sacks and leave for four hours.	Soak seed in water at a temperature of 126° to 128° for five minutes.	....	....	
Cherry leaf blight.	Bordeaux mixture (2), 60-gallon formula, after foliage is fully developed.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	A sixth application may be necessary. The treatment is especially applicable to nursery stock, and the endeavor should be made to keep the upper and lower surfaces of the newly developing foliage covered with the fungicide.
Cherry and plum black knot.	Bordeaux mixture (2), 22-gallon formula, before leaves appear.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	....	The knots should be cut off and burned whenever possible. Painting the cut surfaces with kerosene or linseed oil will tend to prevent their return.
Grape black rot....	Bordeaux mixture (2), 50-gallon formula, before buds open.	Same fungicide when leaves are one-third grown.	Same fungicide just before blooming.	Same fungicide two weeks later.	Ammoniacal copper carbonate solution (1), two weeks later.	A sixth application may be necessary, and it should be made with ammoniacal copper carbonate solution. In dry weather it is probable that the number of sprayings may be less.
Grape downy mildew.	Bordeaux mixture (2), 60-gallon formula, when leaf buds open.	Same fungicide when leaves are half grown.	Same fungicide when plants are in bloom.	Same fungicide when fruit is half grown.	....	As this disease and black rot frequently occur together, the same applications will generally answer for both. If more than four applications be made, as may be necessary in wet seasons, ammoniacal copper carbonate solution should be used to prevent spotting the fruit.

TREATMENT FOR FUNGOUS DISEASES OF PLANTS—Continued.

Disease.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Remarks.
Oat smut	Soak seed for one minute in warm water at 110° (4).	Soak seed in hot water at 132° for ten minutes.	....	....	....	After the second soaking, if not needed for immediate use, the seed should be spread out to dry and then put in clean bags, which have been previously sterilized by heat.
Orange sooty mold.	Resin wash (5) in January or February.	Same wash ten days to two weeks later.	Same wash in May or August.	....	....	Special care should be taken to wet the under surfaces of the leaves. Usually, two sprayings in winter are sufficient.
Peach curl	Bordeaux mixture (2), 50-gallon formula, just before buds unfold.	Same fungicide when leaves are half grown.	Same fungicide two weeks later.	Same fungicide two weeks later.	....	
Pear leaf blight	Bordeaux mixture (2), 50-gallon formula, when buds are swelling.	Same fungicide when leaves are half grown.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	This is especially for the nursery. In the orchard the first and second treatments may be omitted.
Pear scab	Bordeaux mixture (2), 50-gallon formula, when fruit buds open.	Same fungicide just before blossoming.	Same fungicide when petals fall.	Same fungicide when fruit is one-half inch in diameter.	....	
Plum, prune, and peach leaf rust.	Ammoniacal copper carbonate solution (1) when trees cease to bloom and when in leaf.	Same fungicide three weeks later.	Same fungicide two weeks later.	....	....	
Potato rot or blight and Macrosporium disease.	Bordeaux mixture (2), 22-gallon formula, when plants are 6 inches high.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	....	For best results potatoes should be dug as soon as plants wither, not allowing them to remain in the ground until cold weather.
Potato scab	Cut and soak potatoes in corrosive sublimate solution (6) one hour and thirty minutes.	....	....	....	....	
Quince fruit spot and leaf blight.	Bordeaux mixture (2), 60-gallon formula, after blossoms fall.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	A sixth application may be necessary in case of very wet weather.
Wheat stinking smut.	Soak seed for one minute in warm water at 110°–115° (4).	Soak seed for fifteen minutes in hot water (132°).	Cool seed with cold water and spread out to dry.	....	....	

FORMULAS FOR FUNGICIDES.

(1) *Ammoniacal copper carbonate solution:*

Copper carbonate	ounces	5
Ammonia (26 per cent)	pints	3
Water	gallons	50

Place the copper carbonate in a wooden pail and make a paste of it by the addition of a little water. Then pour on the ammonia and stir until all the copper is dissolved. If the 3 pints of ammonia is not sufficient to dissolve the copper, add more until no sediment remains. Pour into a barrel and dilute with 45 or 50 gallons of water, and the mixture is then ready for use.

(2) *Bordeaux mixture:*

Copper sulphate	pounds	6
Strong fresh lime	do	4
Water	gallons	22

In a barrel that will hold 45 gallons dissolve the copper sulphate, using 8 or 10 gallons of water, or as much as may be necessary for the purpose. In a tub or half barrel slake the lime. When completely slaked add enough water to make a creamy whitewash. Pour this slowly into the barrel containing the copper sulphate solution, using a coarse gunny sack stretched over the head of the barrel for a strainer. Finally, fill the barrel half full of water, stir thoroughly, and the mixture is ready for use. The 50 or 60 gallon formula is made in the same way except that 50 or 60 gallons of water is added instead of 22 gallons. For further directions in making large quantities see Bull. No. 6, Div. Vegt. Path., pp. 8-11.

(3) *Potassium sulphide:*

Potassium sulphide	ounces	2½
Water	gallons	5

Dissolve the potassium sulphide in water and the mixture is ready for use.

(4) *Hot water treatment.*

This treatment is used for smuts of oats and wheat. Place two large kettles or two wash boilers on a stove; provide a reliable thermometer and a coarse sack or basket for the seed. A special vessel for holding the grain may be made of wire or perforated tin. The vessel should never be entirely filled with grain, and in the kettles there should be about five or six times as much water by bulk as there is grain in the basket. In the first kettle keep the temperature of the water at from 110° to 130°, and in the other at 132° to 133°, never letting it fall below 130° lest the fungous spores may not be killed, nor rise above 135° lest the grain be injured. Place the grain in the basket and then sink it into the first kettle. Raise and lower it several times or shake it so that all the grain may become wet and uniformly warm. Remove it from the first kettle and plunge it into the second, where it should receive fifteen minutes' treatment. Shake about repeatedly, and also raise the basket containing the grain completely out of the water five or six times during the treatment. If the temperature falls below 132° let the basket remain a few moments longer; if it rises, a few moments less. Have at hand cold and boiling water with which to regulate the temperature. At the expiration of fifteen minutes remove the grain and plunge into cold water, after which spread it out to dry. The seed may be sown at once, before thoroughly dry, or may be dried and stored until ready for use. In treating oats keep them in water at 132° for only ten minutes and spread out to dry without plunging into the cold water.

(5) *Resin wash:*

Resin	pounds	20
Caustic soda (98 per cent)	do	4½
Fish oil (crude)	pints	3
Water to make	gallons	15

Place the resin, caustic soda, and fish oil in a large kettle. Pour over them 13 gallons of water and boil until the resin is thoroughly dissolved, which requires from three to ten minutes after the materials begin to boil. While hot add enough water to make just 15 gallons. When this cools, a fine, yellowish precipitate settles to the bottom of the vessel. The preparation must therefore be thoroughly stirred each time before measuring out to dilute, so as to uniformly mix the precipitate with the clear, dark, amber-brown liquid, which forms by far the greater part of the

stock preparation. When desired for use, take 1 part of the stock preparation to 9 parts of water. If the wash be desired for immediate use, the materials, after boiling and while still hot, may be poured directly into the spray tank and diluted with cold water up to 150 gallons.

(6) *Corrosive sublimate solution :*

Corrosive sublimate	ounces..	$2\frac{1}{4}$
Water	gallons..	15

This solution is used for potato scab. The corrosive sublimate is dissolved in about 2 gallons of hot water, and after an interval of ten or twelve hours diluted with 13 gallons of water. The potatoes to be planted are immersed in the solution for one and one-half hours, after which they are spread out to dry, then cut and planted as usual. A half barrel is a convenient receptacle for the solution. The potatoes may be put into a coarse sack and suspended in the liquid, first washing the tubers. Corrosive sublimate is very poisonous and should be kept out of the way of children and animals. All treated tubers should be planted or destroyed.

GRASSES AS SAND AND SOIL BINDERS.

[Alphabetical list of the grasses mentioned in the article on grasses as sand and soil binders by Professor Lamson-Scribner, with the Latin equivalents of the English names.]

Alkali grass = *Distichlis maritima* Raf. = *Distichlis spicata* Green = *Brizopyrum spicatum* Hook.
Beach grass = *Uniola paniculata* Linn. Also applied to *Ammophila arenaria.*
Bermuda grass = *Cynodon dactylon* Pers. = *Capriola dactylon* Kuntze.
Bitter panic grass = *Panicum amarum* Ell.
Black grama = *Muhlenbergia pungens* Thurb.
Blady grass = *Imperata arundinacea* Cyr.
Broad-leafed spike grass = *Uniola latifolia* Mx.
Coast couch grass = *Zoysia pungens* Willd.
Common reed = *Phragmites communis* Trin. = *Phragmites phragmites* Karst.
Couch grass = *Agropyrum repens* Beauv.
Creeping panic = *Panicum repens* Linn.
Fine-top salt grass = *Sporobolus airoides* Torr.
Fresh-water cord grass = *Spartina cynosuroides* Willd.
Giant rye grass = *Elymus condensatus* Presl.
Hungarian brome grass = *Bromus inermis* Linn.
Indian reed = *Cinna arundinacea* Linn.
Johnson grass = *Andropogon sorghum* var. *Halapense* Hack. = *Andropogon halapensis* Brot. = *Sorghum halapense* Pers.
"Klittag" (Danish) = *Ammophila arenaria* Link.
Knot grass = *Paspalum distichum* Linn.
Knot-root grass = *Muhlenbergia mexicana* Trin.
Long-leafed sand grass = *Calamovilfa longifolia* Hack. = *C. longifolia* Hook.
Long-leafed spinifex = *Spinifex longifolius* R. Br.
Louisiana grass = *Paspalum platycaule* Poir. = *Paspalum compressum* Nees.
"Marehalm" (Danish) = *Elymus arenarius.*
Marram grass = *Ammophila arenaria* Link. = *A. arundinacea* Host. = *Psamma arenaria.*
Pimento grass = *Stenotaphrum americanum* Schrank.
"Rancheria grass" = *Elymus arenarius* Linn.
Redfield's grass = *Redfieldia flexuosa* Vasey.
Reed = *Arundo donax.* (*See* Common reed.)
Reed canary grass = *Phalaris arundinacea* Linn.
Rolling spinifex = *Spinifex hirsutus* Labill.
Running mesquit = *Hilaria cenchroides* H. B. K.
Salt cedar = *Monanthochloë littoralis* Engel.
Salt grass = *Distichlis spicata* Green = *Distichlis maritima* Raf.
Sand reed = *Ammophila arenaria.* (*See* Marram grass.)
Sea lyme grass = *Elymus arenarius* Linn.
Southern wheat grass = *Ischæmum triticeum* R. Br.
St. Augustine grass = *Stenotaphrum americanum* Schrank.
Swamp millet = *Ischæmum australe* R. Br.
Switch grass = *Panicum virgatum* Linn.
Upright sea lyme grass = *Elymus arenarius* Linn.
Usar grass = *Sporobolus orientalis* Kunth.
Water oats = *Uniola paniculata* Linn.
Western rye grass = *Elymus condensatus* Presl.
Witch grass = *Agropyrum repens* Beauv.

TABLE OF ONE HUNDRED WEEDS.

NOTE 1.—This table presents the common and technical name, with some of the characteristics, of one hundred weeds which are regarded as the most troublesome in the United States.

NOTE 2.—By alternate cultivation and smothering crops is meant clean cultivation during the dry season and a heavy seeding of some annual crop, as crimson clover, cowpeas, millet, or oats, that will cover the ground thickly and choke down the weeds during the growing season.

NOTE 3.—Under color and size of flowers the most prominent color and the approximate diameter of the single flower, or of a head in the case of composites, are given.

Common names.	Technical name.	Where injurious.	Duration.	Time of flowering.	Time of seeding.	Color, size, and arrangement of flowers.	Methods of propagation and distribution of seed.	Place of growth and products injured.	Methods of eradication.
Barn grass, barnyard grass, cocksfoot.	Panicum crus-galli	Minnesota to Montana.	Annual ...	June to August.	July to September.	Green; $\frac{1}{8}$ inch; panicle.	Seeds; in green seed.	Fields; spring wheat.	Prevention of seeding.
Black mustard	Brassica nigra	Washington to California.	.....do	June to September.	July to October.	Yellow; $\frac{1}{4}$ inch; panicle.	Seeds; in grass and grain seed.	Fields; grain crops.	Prevention of seeding; hoed crops.
Bracted plantain, rib grass, buckhorn.	Plantago aristata .	Ohio to Iowa...	.....do (?)..	May to October.	June to December.	Green; $\frac{1}{4}$ inch; spike.	Seeds; in grass and clover seed.	Meadows; pastures.	Do.
Brake, eagle fern.........	Pteris aquilina ...	Washington to California.	Perennial .	....	....	Flowerless	Rootstocks; spores.	.....do	Heavy seeding; cultivation.
Broom rape	Orobanche ramosa	Kentucky to N. C.	Annual ...	June to August.	July to September.	White; $\frac{1}{2}$ inch; spike.	Seeds	Hemp; tobacco	Clean seed.
Buffalo bur, beaked horse nettle.	Solanum rostratum	Iowa to Colorado.	.....do	June to September.	July to November.	Yellow; $\frac{1}{2}$ inch	Seeds; tumbleweed.	Grain; hoed crops.	Heavy seeding; close cultivation.
Bull thistle, common thistle.	Carduus lanceolatus.	Everywhere ...	Biennial ..	June to August.	.....do	Purple; 1 inch; head.	Seeds; wind ...	Meadows; winter wheat.	Prevention of seeding; cutting in fall.
Burdock, great dock	Arctium lappa....	New England to Wisconsin.	.....do	July to September.	August to October.	Purple; $\frac{1}{2}$ inch; head.	Seeds; animals.	Waste places; pastures; wool.	Prevention of seeding; grubbing in summer.
Bur grass, hedgehog grass, Rocky Mountain sand bur, sand bur, sand spur.	Cenchrus tribuloides.	Everywhere ...	Annual ...	June to October.	July to November.	Green; bur ...	.....do	Sandy pastures; wool.	Cultivation; burning.
Buttonweed..............	Diodia teres.......	Maryland to Alabama.	.....do	.....do	.....do	Green; 1 line; axillary.	Seeds	Waste places, hoed crops; grainfields.	Prevention of seeding; close cultivation.
Canada thistle	Carduus arvensis.	NewEngland to Michigan.	Perennial .	June to September.	July to October.	Purple; $\frac{3}{4}$ inch; head.	Rootstocks; seeds.	Fields; grain; meadows.	Alternate cultivation and heavy cropping.
Charlock, wild mustard..	Brassica arvensis .	NewEngland to New Jersey.	Annual ...	May to September.	June to October.	Yellow; $\frac{1}{4}$ inch; panicle.	Seeds; in grain seed.	Fields; grain..	Prevention of seeding; cultivation; hoed crops.
Chess, cheat, wheat thief, Willard's brome grass.	Bromus secalinus.	NewEngland to Washington.	.....do	July to September.	August to October.	Green; panicle	.....do	.....do	Clean seed.
Chondrilla, gum succory, skeleton weed, stickweed.	Chondrilla juncea.	West Virginia to Maryland.	Biennial ..	June to November.	July to December.	Yellow; $\frac{1}{2}$ inch; solitary.	Seeds; wind....	Waste places; pastures.	Cultivation; hoed crops.

TABLE OF ONE HUNDRED WEEDS—Continued.

Common names.	Technical name.	Where injurious.	Duration.	Time of flowering.	Time of seeding.	Color, size, and arrangement of flowers.	Methods of propagation and distribution of seed.	Place of growth and products injured.	Methods of eradication.
Clover dodder, devil's gut, dodder.	Cuscuta trifolii....	New York to N. C. and westward.	Annual ...	June to November.	June to November.	Yellow; 1/3 inch; clusters	Seeds; in clover and alfalfa seed.	Clover; alfalfa.	Clean seed.
Cockle, corn cockle, rose campion.	Agrostemma githago.	New England to Washington.	.....do	June to August.	July to September.	Purple; 1 inch; solitary	Seeds; in grain seed.	Grain fields; wheat.	Do.
Cocklebur, clotbur, ditch bur, small burdock.	Xanthium canadense, Xanthium strumarium.	Everywhere ...	.....do	July to October.	August to November.	Green; 1/8 inch; heads.	Seeds; animals.	Waste places; pastures; wool.	Prevention of seeding; cultivation.
Couch grass, quack grass, quick grass, witch grass, devil's grass, durfee grass.	Agropyron repens.	New England to Minnesota.	Perennial .	July to August.	August to September.	Green; spikes.	Rootstocks.....	Fields; all crops except hay.	Alternate cultivation and heavy cropping.
Cow herb, cockle, cow basil, cow fat, glond.	Saponaria vaccaria.	Colorado to Utah.	Annual ...	June to July.	July to August.	Pink; 3/4 inch; cymes.	Seeds; in grain seed.	Fields; grain..	Prevention of seeding; clean seed.
Crab grass, finger grass, Polish millet.	Panicum sanguinale.	New Jersey to Missouri and south.	Perennial .	June to September.	July to October.	Green; spikes.	Seeds	Hoed crops....	Prevention of seeding; closer cultivation.
Curled dock, yellow dock.	Rumex crispus....	New England to Washington.	.....do	.....do	.....do	Green; 1/4 inch; panicle.	.....do	Meadows; grain crops.	Alternate cultivation; heavy cropping.
Dandelion................	Taraxacum taraxacum.	Nearly everywhere.	Biennial ..	May to October.	May to November.	Yellow; 1 inch; head.	Seeds; wind....	Meadows; lawns.	Cultivation.
Devil's weed, devil's paint brush, king devil weed, golden hawkweed.	Hieracium præaltum.	New York	Perennial .	July to September.	August to October.	.....do	Seeds; wind; rootstock.	Meadows; pastures.	Sheep pasturing; cultivation and heavy cropping.
Dog fennel, Mayweed....	Anthemis cotula..	Everywhere ...	Annual ...	June to August.	July to September.	White; 3/4 inch; head.	Seeds	Roadsides.....	Prevention of seeding.
English bindweed, morning-glory.	Convolvulus arvensis.	New England and California.	Perennial .	June to September.	August to October.	White; 1 inch; solitary.	Seeds; rootstocks.	Grain fields; hoed crops.	Prevention of seeding; late cultivation.
False flax, gold of pleasure; wild flax.	Camelina sativa...	Michigan to Minnesota.	Annual ...	May to July	June to August.	Yellow; 1/8 inch; raceme.	Seeds; in flax and grain seed.	Flax and winter grain.	Prevention of seeding.
Fleabane, daisy fleabane, sweet scarbious, whitetop.	Erigeron annuus..	Maine to Minnesota and south.	.....do	June to August.	July to September.	White; 3/8 inch; heads.	Seeds	Waste places; meadows.	Do.
Franseria	Gærtneria discolor.	Wyoming to New Mexico.	Perennial .	.....do	.....do	Yellow; 1/4 inch; heads.	Rootstocks.....	.....do	Thorough cultivation.
Great ragweed, hogweed.	Ambrosia trifida..	Iowa to Louisiana and east.	Annual ...	July to September.	August to October.	.....do	Seeds	Bottom lands..	Cultivation; heavy cropping.
Gum plant, rosinweed, sunflower.	Grindelia squarrosa.	North Dakota to Utah.	.....do	.....do	August to November.	Yellow; 1/2 inch; heads.	Seeds; animals.	Meadows; pastures.	Prevention of seeding; cultivation.

Hedge bindweed, morning-glory.	Convolvulus sepium.	New Jersey to Illinois.	Perennial .	.....do	August to October.	White; 2 inches; solitary.	Seeds	Corn and grain-fields.	Late cultivation.
Hogweed..................	Boerhaavia erecta.	Louisiana to Texas.	Annual ...	June to November.	July to December.	White; $\frac{1}{16}$ inch; cyme.	.....do	Meadows; cultivated land.	Prevention of seeding; thorough cultivation.
Horse nettle, bull nettle, sand briar.	Solanum carolinense.	Iowa to New Jersey and south.	Perennial .	June to October.	August to November.	Purple; 1 inch; solitary.	Seeds; rootstocks.	Waste land; meadows; pastures.	Alternate cultivation and heavy cropping.
Horseweed, butterweed, colt's tail, fleabane.	Erigeron canadensis.	Everywhere ...	Annual ...	June to September.	July to October.	White; $\frac{1}{4}$ inch; head.	Seeds; wind....	Waste land; meadows; grainfields.	Prevention of seeding; late cultivation.
Indian mallow, butter print, stampweed, velvet leaf.	Abutilon avicennæ.	Illinois to Iowa and Missouri.	.....do	July to August.	August to September.	Yellow; $\frac{1}{2}$ inch; solitary.	Seeds	Cultivated lands.	Prevention of seeding.
Jimson weed, Jamestown weed, thorn apple.	Datura tatula.....	Virginia to Texas.	.....do	July to September.	August to October.	Purple; 3 inches; solitary.	.....do	Waste places..	Do.
Johnson and Cuba grass, Australian, Egyptian, and evergreen millet, Means's grass.	Andropogon halepensis.	North Carolina to Texas and California.	Perennial .	June to August.	July to September.	Green; $\frac{1}{8}$ inch; panicle.	Rootstocks; seeds.	Cultivated fields; hoed crops.	Alternate cultivation and heavy cropping.
Lamb's quarters, pigweed.	Chenopodium album.	Everywhere ...	Annual ...	July to September.	August to November.	Green; $\frac{1}{16}$ inch; paticle.	Seeds	Waste places..	Prevention of seeding.
Live forever, garden orpine.	Sedum telephium..	New York to Pennsylvania.	Perennial .	July to August.	August to September.	Purple; $\frac{1}{3}$ inch; cyme.	Rootstocks; seeds.	Fields.........	Infection with fungous disease; close cultivation.
Malva.....................	Malva parviflora..	California......	.....do	June to August.	July to September.	Purple; $\frac{1}{2}$ inch; solitary.	Seeds; rootstocks.	.....do	Prevention of seeding; thorough cultivation.
Manroot, man-of-the-earth, morning-glory.	Ipomœa pandurata.	Delaware to Missouri.	.....do	July to September.	August to October.	White; 3 inches; solitary.	.....do	.....do	Prevention of seeding; killing roots with coal oil.
Marsh elder, high-water shrub.	Iva xanthifolia....	Minnesota to Utah.	Annual ...	August to September.	September to October.	Green; $\frac{1}{4}$ inch; heads.	Seeds	Fields; pastures; grain crops.	Prevention of seeding.
Mexican tea, pigweed....	Chenopodium ambrosioides.	Virginia to Louisiana.	.....do	.....do	August to October.	Green; $\frac{1}{16}$ inch; spikes.	.....do	Waste places..	Do.
Milkweed, cottonweed, silkweed.	Asclepias syriaca.	New York to Nebraska.	Perennial .	July to August.	August to September.	Purple; $\frac{1}{2}$ inch; umbel.	Seeds; wind; rootstocks.	Fields.........	Prevention of seeding; cultivation, heavy cropping.
Morning glory	Ipomœa nil, Ipomœa purpurea.	Delaware and California.	Annual ...	July to November.	August to December	Purple; 2 inches; solitary.	Seeds	Cultivated fields.	Prevention of seeding; thorough cultivation.
Moth mullein	Verbascum blattaria.	Maryland to Ohio, Oregon.	Biennial ..	June to October.	July to November.	Yellow; $\frac{3}{4}$ inch; raceme.	Seeds; in grass seed.	Meadows	Clean seed; cultivation; grub in fall.
Musky alfilerilla, ground needle, musky heronbill	Erodium moschatum.	California to Arizona.	Annual ...	April to July.	May to August.	Rose; $\frac{3}{4}$ inch; umbel.	Seeds	Pastures	Sowing clean seed; burning.
Narrow-leafed stickseed, beggar tick.	Lappula lappula ..	Everywhere ...	.....do	July to September.	July to October.	Blue; $\frac{1}{8}$ inch; raceme.	Seeds; animals.	Everywhere; all crops.	Sowing clean seed; cultivation.

TABLE OF ONE HUNDRED WEEDS—Continued.

Common names.	Technical name.	Where injurious.	Duration.	Time of flowering.	Time of seeding.	Color, size, and arrangement of flowers.	Methods of propagation and distribution of seed.	Place of growth and products injured.	Methods of eradication.
Nut sedge, nut grass, coco, coco sedge.	Cyperus rotundus.	Maryland to Arkansas and Texas.	Perennial	July to October.	August to November.	Brown; $\frac{1}{16}$ inch; spikelets.	Tubers; in nursery packing; seeds.	In hoed crops	Alternate cultivation and smothering crops.
Orange hawkweed, ladies' paint brush, red daisy.	Hieracium aurantiacum.	New York	do	July to September.	August to October.	Orange; $\frac{1}{2}$ inch; solitary.	Seeds; wind; rootstocks.	Meadows; pastures.	Prevention of seeding; cultivation.
Ox-eye daisy, bull's-eye, white daisy, whiteweed.	Chrysanthemum leucanthemum.	Maine to Virginia and Ohio.	do	June to September.	July to October.	White; 1 inch; solitary.	Seeds; rootstocks.	do	Do.
Paraguay bur, sheep bur.	Acanthospermum xanthioides.	North Carolina to Florida.	do	May to November.	June to December.	Yellow; $\frac{1}{4}$ inch; heads.	Seeds; animals; rootstocks.	Waste places; pastures; wool.	Cultivation.
Paroquet bur	Sida stipulata	Alabama to Florida.		June to November.	July to December.	Yellow; 1 inch; solitary.	Seeds; animals.	Waste places; cultivated land; wool.	Do.
Passion flower, maypop	Passiflora incarnata.	North Carolina to Florida.	Perennial	July to September.	August to October.	White; 2 inches; solitary.	Seeds	Hoed crops	More thorough cultivation; prevention of seeding.
Pennycress, Frenchweed.	Thlaspi arvense	North Dakota to Minnesota.	Annual	May to November.	June to December.	White; $\frac{1}{8}$ inch; raceme.	Seeds; wind	Grainfields; pastures; dairy products.	Burning; thorough cultivation.
Pigeon grass, foxtail, yellow foxtail.	Setaria glauca	Everywhere	do	June to September.	July to November.	Green; $\frac{1}{16}$ inch; spikes.	Seeds; in clover seed.	Cultivated land; grain crops.	Do.
Pigweed, careless weed, rough amaranth.	Amarantus retroflexus.	do	do	July to October.	August to November.	Green; $\frac{1}{16}$ inch; spikes.	Seeds	Cultivated land; all crops.	Prevention of seeding; thorough cultivation.
Poison ivy, poison oak, poison vine.	Rhus radicans	do	Perennial	June to July.	July to August.	Yellow; $\frac{1}{4}$ inch; raceme.	Rootstocks; seeds.	Waste land; poisonous to man.	Cultivation; repeated grubbing.
Poverty weed	Iva axillaris	Montana to New Mexico.	do	June to August.	July to September.	Yellow; $\frac{1}{4}$ inch; heads.	Rootstocks; seeds.	Cultivated land; all crops.	Closer cultivation; smothering crops.
Prickly lettuce, compass plant, milkweed, wild lettuce.	Lactuca scariola	Ohio to Iowa and Utah to Oregon.	Annual	June to October.	July to November.	do	Seeds; wind	Everywhere; all crops.	Prevention of seeding; burning.
Purslane, garden purslane, pursley, pusley.	Portulaca oleracea.	Everywhere	do	May to November.	June to December.	Yellow; $\frac{1}{4}$ inch; solitary.	Seeds	Cultivated land; garden crops.	Closer cultivation.
Ragweed, bitterweed, hogweed, richweed, Roman wormwood.	Ambrosia artemisiæfolia.	do	do	July to October.	August to November.	do	Seeds; wind	Everywhere; all crops.	Prevention of seeding; burning.
Rattlebox	Crotalaria sagittalis.	Iowa to South Dakota.	do	July to September.	do	do	Seeds	Pastures; poisonous to stock.	Cultivation.

Rib grass, black plantain, buckhorn, deer tongue, English plantain, lance-leafed plantain, ripple grass.	Plantago lanceolata.	Nearly everywhere.	Perennial	June to October.	July to November.	White; 1/16 inch; spike.	Seeds; rootstocks.	Everywhere; all crops.	Clean seed; cultivation.
Running briar, dewberry, low blackberry.	Rubus canadensis.	Maryland to N. Carolina.	....do....	May to July.	June to August.	White; 1 inch; solitary.	Seeds; birds; rootstocks.	Fields; all crops.	Cultivation; smothering crops.
Russian thistle, Russian cactus, Russian tumbleweed, Russian saltwort.	Salsola kali tragus.	Minnesota to Colorado.	Annual	July to September.	August to November.	Purplish; 1/4 inch; solitary.	Seeds; wind...	Everywhere; small grain.	Cultivation; burning.
Shepherd's purse, mother's heart, pickpurse, toothwort.	Bursa bursa-pastoris.	Everywhere	....do....	March to December.	May to December.	White; 1/16 inch; raceme.	Seeds	Everywhere; all crops.	Cultivation.
Small carrot, bristly and Southern wild carrot.	Daucus pusillus...	Georgia to Arizona.	....do....	June to July.	July to August.	White; 1/8 inch; umbel.	Seeds; animals; wind.	....do....	Prevention of seeding; cultivation.
Smartweed, knotweed....	Polygonum pennsylvanicum.	Ohio to Nebraska.	....do....	July to August.	August to September.	Pink; 1/16 inch; spike.	Seeds	....do....	Do.
Sneezeweed	Helenium autumnale.	North Carolina to Texas.	Perennial	July to September.	August to October.	Yellow; 1/2 inch; head.	Seeds; rootstocks.	Meadows; pastures.	Cultivation.
Sorrel, field sorrel, horse sorrel, red sorrel, sheep sorrel, sourweed.	Rumex acetosella.	Nearly everywhere.	....do....	May to October.	June to November.	Red; 1/8 inch; panicle.	Seed, in clover seed; rootstocks.	....do....	Cultivation; smothering crops.
Sorrel dock, sour dock....	Rumex acetosa....	South Carolina to Georgia.	....do....	....do....	....do....	Reddish; 1/8 inch; panicle.	Seeds; rootstocks.	....do....	Thorough cultivation.
Sow thistle, field sow thistle, perennial sow thistle.	Sonchus arvensis..	New England to Wisconsin.	....do....	July to October.	August to November.	Yellow; 3/4 inch; heads.	Seeds; wind; rootstocks.	Meadows; pastures; grain-fields.	Thorough cultivation and smothering crops.
Spanish needles, bur marigold, beggar ticks.	Bidens bipinnata..	Everywhere	Annual	June to September.	July to November.	....do....	Seeds; animals.	Waste land; pastures.	Prevention of seeding.
Spiny amaranth, spiny careless weed, red careless weed.	Amaranthus spinosus.	Virginia to Texas.	....do....	July to November.	August to December.	Green; 1/16 inch; spikes.	Seeds	....do....	Do.
Spiny nightshade	Solanum aculeatissimum.	North Carolina to Mississippi.	....do....	June to September.	July to October.	White; 1 inch; raceme.	....do....	Waste places; pastures.	Prevention of seeding; cultivation.
Spiny cocklebur, Bathurst bur, Chinese thistle, dagger cocklebur.	Xanthium spinosum.	Maryland to Texas and California.	....do....	July to October.	August to November.	Green; 1/2 inch; head.	Seeds; animals.	Waste land; pastures; wool.	Do.
Squirrel tail, foxtail, wild barley.	Hordeum jubatum	Texas to Utah..	....do....	June to September.	July to October.	Green; spike..	Seeds; wind; animals.	Pastures	Do.
Star thistle, Texas thistle.	Centaurea americana.	Texas to Oklahoma.	....do....	June to August.	July to September.	Purple; 2 inches; heads.	Seeds; wind....	Cultivated land.	Prevention of seeding; thorough cultivation.
Stubble spurge, spotted spurge.	Euphorbia nutans.	Maryland to Missouri.	....do....	July to October.	August to November.	White; 1/4 inch; cyme.	Seeds	....do....	Prevention seeding; burning stubble.
Sunflower, common sunflower.	Helianthus annuus.	Nebraska to Louisiana.	....do....	July to September.	August to October.	Yellow; 1 1/2 inch; heads.	....do....	....do....	Prevention of seeding.
Tarweed	Madia sativa	Washington to California.	....do....	May to October.	June to November.	Yellow; 1/2 inch; heads.	Seeds; animals.	Roadsides; cult. land.	Prevention of seeding; burning.
Toadflax, butter-and-eggs, devil's flax, impudent lawyer, ramstead, snapdragon.	Linaria vulgaris..	New England to Wisconsin.	Perennial	July to October.	August to November.	Yellow; 1/2 inch; raceme.	Rootstocks; seeds.	Meadows; pastures.	Cultivation; heavy cropping.

TABLE OF ONE HUNDRED WEEDS—Continued.

Common names.	Technical name.	Where injurious.	Duration.	Time of flowering.	Time of seeding.	Color, size, and arrangement of flowers.	Methods of propagation and distribution of seed.	Place of growth and products injured.	Methods of eradication.
Teasle, English thistle, fuller's card, Hutton-weed, Indian thistle.	Dipsacus sylvestris.	Ohio to Tennessee.	Biennial	July to September.	August to October.	White; 1 inch; head.	Seeds	Meadows; pastures.	Prevention of seeding; cultivation.
Tumbleweed, pigweed	Amaranthus albus	Minnesota to Kansas.	Annual	August to Sept.	....do	Green; $\frac{1}{16}$ inch; spike.	Seeds; wind	Cultivated land.	Prevention of seeding; burning.
Vipers bugloss, blue thistle, blueweed.	Echium vulgare	New York to N. C.	Biennial	June to October.	July to November.	Blue; $\frac{1}{2}$ inch; thyrsus.	Seeds	Meadows; pastures.	Alternate cultivation.
Wheat thief, corn gromwell, field gromwell, pigeonweed, redroot.	Lithospermum arvense.	Michigan to Ohio.	Annual	June to September.	July to October.	White; $\frac{1}{4}$ inch; solitary.	Seeds, in grain seed.	Grainfields	Sowing clean seed; cultivation with hoed crops.
Wild buckwheat, black bindweed.	Polygonum convolvulus.	Michigan to N. Dak.	....do	....do	....do	White; $\frac{1}{4}$ inch; raceme.	....do	Grain and corn fields.	Sowing clean seed; cultivation.
Wild carrot, bird's nest, devil's plague, Queen Anne's lace.	Daucus carota	New England to Virginia.	Biennial	June to October.	July to November.	White; $\frac{1}{8}$ inch; umbel.	Seeds; animals; wind.	Meadows; pastures	Grubbing in fall; cultivation.
Wild gourd	Cucurbita perennis.	California to New Mexico.	Perennial	April to July.	June to September.	Yellow; solitary.	Seeds	Cultivated land.	Killing the roots with coal oil.
Wild mustard, charlock, yellow mustard.	Brassica sinapistrum.	New England to Oregon.	Annual	June to September.	July to October.	Yellow; $\frac{1}{2}$ inch; raceme.	....do	Grainfields	Prevention of seeding; hoed crops.
Wild oats	Avena fatua	Minnesota to Oregon.	....do	July to August.	July to September.	Green; $\frac{3}{4}$ inch; panicle.	Seeds, in seed oats.	Oatfields	Clean seed; burning; pasturing.
Wild onion, field garlic, wild garlic.	Allium vineale	Pennsylvania to South Carolina.	Perennial	....do	August to September.	White; $\frac{1}{8}$ inch; umbel.	Bulblets; seeds.	Everywhere; dairy products; grain.	Alternate cultivation and heavy cropping.
Wild parsnip, queenweed.	Pastinaca sativa	New England to Wisconsin.	Biennial	June to September.	July to October.	Yellow; $\frac{1}{8}$ inch; umbel.	Seeds	Meadows; pastures.	Prevention of seeding; cultivation.
Wild senna, teaweed	Cassia marylandica.	Maryland to Texas.	....do	June to July	July to August.	Yellow; $\frac{3}{4}$ inch; raceme.	Seeds; rootstocks.	Cultivated land.	Cultivation and smothering crops.
Wild tobacco	Nicotiana attenuata.	California to Arizona.	Annual	May to July	June to August.	White; $\frac{1}{4}$ inch; raceme.	Seeds	Cultivated and waste land.	Prevention of seeding.
Yellow daisy, brown-eyed Susan, cone flower, niggerhead, ox-eye daisy.	Rudbeckia hirta.	New England to Ohio.	Biennial	June to August.	July to September.	Yellow; 1 inch; head.	....do	Meadows; pastures.	Prevention of seeding; cultivation.
Yellow dock, bitter dock, broad-leafed dock.	Rumex obtusifolius.	New England to Wisconsin.	Perennial	July to September.	August to October.	Green; $\frac{1}{8}$ inch; raceme.	....do	Meadows; pastures.	Do.
Yellow dog fennel	Helenium tenuifolium.	Nebraska to Mississippi.	Annual	July to October.	August to November.	Yellow; $\frac{1}{4}$ inch; head.	....do	Waste land; pastures.	Do.
Yerba mansa	Anemopsis californica.	California to Arizona.	Perennial	May to September.	June to October.	White; $\frac{1}{4}$ inch; spike.	Rootstocks; seeds.	Moist and cultivated land.	Alternate cultivation and heavy crops.

FARMERS' BULLETINS.

Applications for bulletins of this series should be addressed to the Secretary of Agriculture, Washington, D. C., stating both the *number* and *title* of the bulletin desired.

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